EVALUATION OF CULTIVARS AND CULTURAL PRACTICES OF SEVERAL CROPS FOR TROPICAL MULTIPLE CROPPING

By

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TO

THE MEMORY OF MY FATHER, THE LATE JANAB ALI AKHANDA, WHOSE LAST ADVICE "CONTINUE EDUCATION EVEN AT THE COST OF ALL MY PROPERTIES" PRIOR TO HIS LAST BREATH INSPIRED ME AT ALL TIMES

MY MOTHER, AMENA KHATUN, FOR HER SPIRITUAL SUPPORT THROUGHOUT

MY WIFE, MINU, OUR DAUGHTER, FLORA, AND TWO SONS, PHILIP AND TUSHAR, FOR THEIR UNFAILING LOVE TO ME AND COOPERATION IN THIS RESEARCH

FINALLY THE HUNGRY PEOPLE IN THE TROPICS

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EVALUATION OF CULTIVARS AND CULTURAL PRACTICES OF SEVERAL CROPS FOR TROPICAL MULTIPLE CROPPING

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Appropriate crop cultivars, row widths, plant populations and time of planting are essential aspects in developing successful multiple cropping systems. Investigations were conducted to develop soybean (*Glycine max* (L.) Merr.) cultivars suitable for late planting in double cropping systems, examine the effect of row widths and plant populations on agronomic characteristics of sorghum (*Sorghum bicolor* (L.) Moench) and sunflower (*Helianthus annuus* L.) and the possibility of intercropping peanut (*Arachis hypogaea* L.), pigeonpea (*Cajanus cajan* L. Druce) and sweet potato (*Ipomoea batatas* (L.) Lam.) in early-, medium- and late-maturing corn (*Zea mays* L.) at three populations at Gainesville, Florida, in 1976 and 1977.

Length of life cycle, plant height, lowest pod height and seed yield of soybeans planted on August 3 and 6 were less than July 15 and 20 plantings. The period from planting to flowering was the most important factor affecting the life cycle of soybeans. Plant height, bottom pod height, life cycle and seed yields ranged, respectively, from 24 to 112 cm, 0 to 33 cm, 83 to 116 days and 820 to 4,550 kg/ha among the cultivars in July and August plantings in both years.

Seed yields were positively correlated with flowering period ('r' = 0.35** to 0.44**), pod filling period ('r' = 0.35** to 0.49**), plant height ('r' = 0.25* to 0.27*) and length of life cycle ('r' = 0.34* to 0.37*). Bottom pod height was directly related with planting to flowering days ('r' = 0.40** to 0.54**), and plant height ('r' = 0.61** to 0.80**). Several entries were acceptable for lowest pod height to avoid combine harvest loss in both July and August plantings. As compared to the commercial varieties for normal planting, the entries F73-9564, F71-1606 and F72-5823 have better potential for late-July planting and F74-3510, F74-9458 and F74-2122 for early-August planting as a second crop.

With increasing population of sorghum, LAI and panicle length, respectively, increased and decreased significantly, plant height increased as plant population increased from 20 to 30 plants/m^2 and remained the same with further increase in population. The grain yield increased at a rate of 132 kg/ha for each increase of one plant/m^2 from 20 to 30 plants/m^2 and then decreased by 2 kg/ha for each further increase of one plant/m^2 ($\hat{Y} = 1759 + 132X - 2X^2$; $R^2 = 0.82^*$). Grain yield was highest (4,130 kg/ha) from 30 plants/m^2 followed by 3,680 kg/ha from 40 plants/m^2 and lowest (3,550 kg/ha) from 20 plants/m^2. Pioneer B-815 and Bird-A-Boo II sorghum cultivars required 1,700 and 1,543 GDD, respectively, for completing their life cycles.

The plant height and LAI of sunflower increased significantly from 163 cm and 3.35 at 4 plants/m^2 to 83 cm and 7.49 at 8 plants/m^2, respectively, with 'r' values of 0.75** and 0.94**. Seed yield (2,750 kg/ha) was highest at the highest population. Yields were increased by 167 and 122 kg/ha, respectively, for each increase of one plant/m^2 and one unit of LAI with 'r' values of 0.66** and 0.85**. The diameter of

stem and head and 100-seed weight sharply decreased from 2.62 and 21 cm and 5.14 gm at 4 plants/m^2 to, respectively, 1.96 and 15 cm and 4.34 gm at 8 plants/m^2 with 'r' values of -0.84**, -0.96** and -0.64** between them indicating a serious intraspecific competition. Interstate 891 produced the highest yield (2,670 kg/ha) as well as highest total oil (1,220 kg/ha). Oil of all cultivars contained 91% unsaturated fatty acids. Neither the row width nor its interaction with population had any significant effect on sunflower and sorghum yield.

Intercrops did not affect corn yields. Increasing plant population from 2.4 to 4.8 plants/m^2 promoted yield. McNair 508 produced most (7,240 kg/ha) at 4.8 plants/m^2 followed by Pioneer 3369A (7,150 kg/ha) at 4.8 plants/m^2 and Pioneer 3780 (6,970 kg/ha) at 7.2 plants/m^2 with no difference among them. Yields of all intercrops were low indicating the tremendous shading effect of corn on them. Forage and/or seed yields of intercrops were usually highest in early maturing corn at lowest population. Peanut yields were reduced from 3,360 kg/ha as pure stand to 600 kg/ha as intercrop whereas sweet potato yields decreased from 12,700 kg/ha to 2,230 kg/ha. The beginning of flowering in all intercrops was delayed from three to five weeks as compared to pure stands. Most of the intercrop plants etiolated greatly at high corn population.

Selected cultivars of peanut and pigeonpea can be interplanted in early- and medium-maturing corn at plant populations up to 4.8 plants/m^2. Double cropping offers greater possibilities for increasing production per unit of land than does intercropping but it needs longer time.

INTRODUCTION

The world population growth rate is alarming. The food shortage in many parts of the world is critical. It is estimated that one out of six persons in the world, mostly in the developing countries which account for 70 percent of the present world population, is undernourished (Wharton, 1977). Meeting this critical food shortage is a big challenge for mankind at the present time. The world agronomists are greatly concerned. Consequently, The American Society of Agronomy organized several symposia recently with the themes "Maximum crop yields - the challenge" in 1967 (ASA, 1967), "Moving off the yield plateau" in 1970 (ASA, 1971), "All-out food production" in 1974 (ASA, 1975) and with a renewed interest "Agronomists and food: contributions and challenges" in 1976 (ASA, 1977). However, the possibility of bringing more land area into food crops for increasing food production in the future is very bleak in many countries, particularly in Asia where the problem is more acute. Probably the best alternative is to increase production per unit area per day by improved management practices in an intensive cropping pattern such as multiple cropping where climatic conditions permit. Multiple cropping is the cropping system of growing more than one crop on the same land in a year (Harwood, 1973).

Farmers have been using multiple cropping for thousands of years. Researchers have investigated the effects of crop rotation and sequence

of crops on total productivity for many years. The modern concepts of multiple cropping, however, are new. The new concepts are to apply modern technology in the utilization of land, labor, solar radiation, water and time to achieve astounding levels of food production. According to Bradfield (1970), the most important thing in multiple cropping is to minimize the number of days the land is idle during the year. Selection of suitable genotypes as well as phenotypes is the first and most important step in developing cropping systems for particular soil and climatic conditions. Francis et al. (1976) suggested that varieties to be recommended for multiple cropping be screened separately from those for monoculture. Finlay (1974a) indicated some doubt that the best cultivars for monocropping are also the best for multiple cropping. Genetic differences in growth habits, plant types, flowering and fruiting characteristics, life cycle and yield potentials are highly variable among crop species as well as among the cultivars of the same species. A cultivar may be excellent for monoculture within a time frame at a particular spacing but not at all suitable to fit into a multiple cropping system. Early maturing cultivars with substantial yield potential are highly desirable in multiple cropping particularly where the growing season is limited by temperature, moisture or any other climatic factors (Herrera and Harwood, 1973). Adjustment of planting time, plant population and management techniques are all important in a multiple cropping system (ASPAC, 1974). Inter- and intraspecific interference (competition) between plant populations can have a stimulating as well as a hindering effect (Harper, 1964).

Most of the tropical countries with their high population and small farms, improverished farmers and inadequate diets, have resources of solar radiation, land and water, which are not fully exploited under the prevailing systems of management. If practical methods for using these resources more efficiently can be developed, food production can be increased, and their standard of living raised. Aside from production, multiple cropping is particularly advantageous for small farmers, because it involves less risk than does monoculture (Norman, 1970). Therefore, the development of labor-intensive forms of multiple cropping will increase food production, reduce rural-urban migration and expand the purchasing power of low income farmers as a fundamental to long range national development (Dorner and Felstehausen, 1970).

The high-yielding, short season varieties of food crops, such as rice, wheat, corn, soybean, sorghum and peanut, recently developed by plant breeders, provide an obvious opportunity to increase cropping intensities in the tropics and subtropics. Research results at various locations in South and Southeast Asia offer solid evidences that it is possible to develop management practices that will double and in some cases triple the number of crops that can be successfully grown annually. The quick turnaround between the harvest of one crop and the planting of the next has contributed in large measure to the success of crop intensification, particularly through double cropping, in China (Brady, 1977). Double cropping and intercropping with early-maturing cultivars are likely to use environmental resources more

efficiently than monoculture particularly in subtropical regions where the length of warm growing season is limited by low temperature.

The variable and in some cases peculiar characteristics of plants of different food crop species call for intensive studies in developing multiple cropping systems for different geographic and climatic regions. Sorghum, having an amazing capacity of tillering, can produce equally high yields over a great range of plant population. Sunflower, being highly phototropic, has a peculiar process of nutation which suggests that it would use the solar radiation more efficiently than others in a mixture of plant species. The growth habits, branching pattern, leaf distribution, height and rooting are quite different in corn, sorghum, soybean, sunflower, peanut, sweet potato and pigeonpea. These attributes along with the fact that their critical life cycles may not overlap in mixed and intercropping, offer promise for more effective use of the soil and atmospheric resources in multiple cropping. But the available information from research to date on the management of multiple cropping is too fragmented. Much needs to be learned about planting dates, row spacing, and population density for the various crop combinations as well as developing new combinations not presently used by farmers. Plant breeders have traditionally focused their efforts towards improving yields of single-crop stands. Appropriate cultivars of various crops must be developed both by breeding anew and screening from the existing ones for use in very early and late plantings as well as in various forms of multiple cropping.

Investigations were initiated to (1) select suitable soybean cultivars for use as a late-planted second crop in a warm season double cropping system, (2) study the influence of row widths and plant populations on the seed yields and yield components of sorghum and sunflower, and (3) check the possibility of intercropping peanut, pigeonpea and sweet potato in early-, medium-, and late-maturing corn hybrids at three plant populations under high levels of mechanization in a series of experiments.

LITERATURE REVIEW

Multiple Cropping Systems in the Tropics

Multiple cropping has been defined as the intensification of cropping in time and space dimensions and growing two or more crops on the same field in a year (Andrews and Kassam, 1976). The history of multiple cropping is not clearly known. Dalrymple (1971) reported that the development of double cropping in Babylon (in Iraq where civilization began) and Egypt closely paralleled the growth of irrigation systems which started 4,000 to 6,000 years ago in the Tigris-Euphrates river deltas in Babylon and 3,000 to 5,000 BC along the Nile river in Egypt. He also indicated from the historical evidences that multiple cropping started 3,000 BC in India, 1,012 AD in China and in the 13th century in Japan. In the early and mid-20th century King (1927) and Iso (1954) gave detailed accounts of multiple cropping systems in China, Korea, Japan and Taiwan. The history of multiple cropping is old but the modern concepts of multiple cropping under improved technology are new. The various forms of multiple cropping do not occur haphazardly, but rather follow geographical and energy gradients. The most complex and intense forms of intercropping occur in areas where temperature and moisture do not limit growth during most of the year. As temperature and moisture become more limiting with increasing altitude and/or decreasing rainfall, multiple cropping patterns shift to sequential cropping (Ruthenberg, 1976). Multiple

cropping is also more intense where power sources are largely human or animal, such as the small farms in the tropics. It is less prevalent in capital and energy-intensive systems typical of U. S. agriculture. The most complex and sophisticated forms of intercropping are practiced on farms ranging from 5 ha of arable land to less than 7 ha (Sanchez, 1976). Moomaw and Hedley (1971) discussed the salient features of cropping systems throughout the tropics.

The classification of different forms of multiple cropping with their definitions according to Dalrymple (1971), Harwood (1973) and Andrews and Kassam (1976) appears below:

I. SEQUENTIAL CROPPING: Growing two or more crops per year in sequence on the same field. Crop intensification is only in time dimension.

- 1.1 Double cropping: Growing two crops a year in sequence.
- 1.2 Triple cropping: Growing three crops a year in sequence.
- 1.3 Quadruple cropping: Growing four crops a year in sequence.
- 1.4 Ratoon cropping: The cultivation of crop regrowth after harvest, although not necessarily for grain.

II. INTERCROPPING: Growing two or more crops simultaneously on the same field. Crop intensification is in both time and space dimensions.

- 2.1 Mixed cropping: Growing two or more crops simultaneously with no distinct row arrangement.
- 2.2 Row intercropping: Growing two or more crops simultaneously where one or more crops are planted in rows.

2.3 Strip intercropping: Growing two or more crops simultaneously in different strips wide enough to permit independent cultivation, but narrow enough for the crops to interact agronomically.

2.4 Relay intercropping: Growing two or more crops simultaneously during part of the life cycle of each. A second crop is planted after the first crop has reached its reproductive stage of growth but before it is ready for harvest.

Based on the interactions among component crops in multicropping, Hart (1974) classified multiple cropping systems as follows:

Commensalistic polyculture: The interaction between crop species has a positive net effect on one species and no observable effect on the other species.

Amensalistic polyculture: The interaction between crop species has a negative effect on one species and no observable effect on the other species.

Monopolistic polyculture: The interaction between crop species has a positive net effect on one species and a negative net effect on the other species.

Inhibitory polyculture: The interaction among crop species has a negative effect on all species.

Various other widely used terms related to cropping systems are defined (according to Ruthenberg, 1976,and Andrews and Kassam, 1976) as follows:

Sole cropping: One crop variety grown alone in pure stands at normal density. Synonymous with solid planting; opposite of intercropping.

Monoculture: The repetitive growing of the same crop on the same land.

Cropping pattern: The yearly sequence and special arrangement of crops or crops and fallow on a given area.

Cropping system: The cropping patterns used on a farm and their interaction with farm resources, other farm enterprises, and available technology which determine their makeup.

Mixed farming: Cropping systems which involve the raising of crops, animals, and/or trees.

Cropping index: The number of crops grown per annum on a given area of land x 100.

Land Equivalent Ratio (LER): The ratio of the area needed under sole cropping to one of intercropping at the same management level to give an equal amount of yield. LER is the sum of the fractions of the yields of the intercrops relative to their sole crop yields.

The socio-economic conditions leading to intensive multiple cropping in the tropics are round-the-year hospitable climate for growing crops, small and fragmented farms, poor farmers, abundance of human resources (underemployment), lack of alternate employment opportunity, and shortage of food. The intensification of land and labor utilization through intensive multiple cropping systems is a promising alternative for increasing food production and employment in rural areas, the

sector where the problems of low income and malnutrition are most acute (Gomez, 1974). The socio-economic conditions are further aggravated in the absence of industrial development. Ruthenberg (1976) also indicated that under conditions of land shortage and ample labor supply, different forms of mixed cropping, phased planting and overlapping cycles of vegetation seemed to be compatible with improved farming provided row cultivation is practiced. Krantz et al. (1976) found that risk reduction in unfavorable years, more profitable and more stable production in both good and bad years, improved soil fertility management by intercropping legumes and nonlegumes, conservation of the soil through improved cover conditions and efficient labor distribution are the main reasons for adapted multiple cropping in the tropics. In another study (1974) they found that multiple cropping with its quicker, greater and longer crop cover offers a better and stable yield-producing system. Conway and Romm (1972) stated that diversified cropping systems can be designed which control pests and diseases by their internal dynamics by manipulating the agroecosystems. Litsinger and Moody (1976) concluded that crop diversity in close proximity is crop protection. The above evidences are enough to justify the popularity of multiple cropping systems in the tropics.

Various multiple cropping systems with different cropping intensity, influenced by climate, soil, market and social factors, are found in the tropics. Dalrymple (1973) found that the country averages for cropping intensity or land equivalent ratio ranges from 1.1 in Burma to 1.84 in Taiwan. Lunan (1950) reported various

multiple cropping systems with cassava, sweet potato, chickpea and wheat in Africa. Sierra Leone (1955) indicated multiple cropping systems with cowpea, yam, rice and cassava as mixed crops in complex mounds, ridges and furrows. Pinchinat et al. (1976) observed corn, various beans, cassava, cacao and coffee, banana and legumes in year-round multiple cropping systems in tropical America. However, in Asia multiple cropping systems are based on rice as the principal crop. Streeter (1972) reported that from a five-crop rotation, two tons of rice, ten tons of sweet potato, one ton of soybean grain, 18,000 ears of sweet corn and 6,000 pounds of green soybean pods were produced on one acre in a year in the Philippines. The original author of this research, Bradfield (1972) claimed that the dollar return was $3,150/ha from the above five-crop rotation. One-fourth of that value was for the sweet corn ears which are perishable and generally not liked by Asian peoples. IRRI (1972) reported that 26 t/ha of rough rice from four sequential rice crops was obtained in 335 days. Considering this period as a full year, the production per day was 71 kg of rough rice. The amount of milled rice/day was 46 kg at 65% milling recovery. This amount of milled rice can meet the daily cereal grain requirement of more than 200 people at the international standard of 236 gm/day/person. It looks extremely attractive in solving the food problem of the hungry nations in the tropics. On the other hand, Luh (1969) found through a survey that as many as 9 crops per year are raised by vegetable farmers in Hong Kong and Vietnam.

The agroecosystem in the humid tropics has been characterized by Harris (1972) as having diverse assemblage of crops in poly-cultural pattern of structural and functional interdependence. Holdridge (1959) proposed that one potentially successful tropical agroecosystem strategy might be to plant a 'mixed culture' simulating as far as possible the natural process of succession of vegetation, as found in undisturbed natural forest. Asian small farms are characterized by a diversity of crops, animals and off-farm enterprises which contribute to the cash flow of the farming system and a homestead production area which is aimed primarily at farm family comfort and subsistence (Harwood and Price, 1976). The area around the house or farmyard is normally planted to a wide assortment of crops which not only offer shelter and privacy but also contribute diversity and quality to the diet of the farm family. The plant components of the system generally consist of 5-6 tall-growing tree species (coconut or other fruit), 5-6 medium-height tree species, 5-6 bush or shrub species, 4-5 root crops and up to 30 shade-tolerant, short statured or vine-type annuals. This is a typical cropping system in the homestead in Bangladash, India and many other Asian countries.

The systems available for multiple cropping in the tropics are numerous. Basically any cropping system is designed to control and make use of the environemtnal resources as efficiently as possible. Again, considering the visible radiation, extra days gained from a cropping system mean extra energy for utilization in this energy short world.

Component Crops in Multiple Cropping

The compatibility of different crop species determines the potentials of the species to become component crops in multiple cropping systems. The compatibility is measured or judged by the growth habits, canopy structures, life cycles and competition for light, water, nutrients and other essentials for growth. Miller (1969) defined the competition as "the active demand by two or more individuals of the same species (intraspecific competition) or by members of two or more species (interspecific competition) for a common resource that is actually limiting. Haizel and Harper (1973) studied the effect of population density in a series of experiments with mixtures of barley, oats and mustard and found that doubling the density of an introduced crop did not double the damage to the crop already present. An exception to the generalization that the negative effect of interspecific competition was found with oat interplanted in barley and mustard. Mann and Barnes (1953) studied the effect of plant density in clover and ryegrass mixture (polyculture) and found that increasing the density of clover by 300% reduced the density of ryegrass by only 40%. Summarizing the research of many investigators, Odum (1969) classified interaction between a two-species population as negative, neutral or positive according to the effect of interaction on individual species.

The nature of crop competition and compatibility was studied by many researchers. Blackman and Templeman (1970) having observed the interaction between barley and weeds suggested that light becomes

a limiting factor when high levels of nitrogen are applied. Donald (1963) observed that when water and nutrients are not limiting, light becomes the limiting factor and growth of the shaded short plant is depressed. A smaller root system results, further limiting the capacity of the shorter crop to compete for water and minerals. The weaker competitor may not be able to absorb elements that fall below certain threshold levels because of their accelerated removal by the stronger competitor. If moisture becomes limiting, the shaded plants may have better growth because the plants are under less moisture stress. He also concluded that the yield of a mixture will usually be lower than the highest yielding crop in a monoculture, higher than the lowest yielding crop in a monoculture and may be greater or less than the mean yield of all the crops planted in monocultures. Kaserer (1911) noted that there is little or no interpenetration of plant roots of the same species when they are grown together, whereas a significant degree of root interpenetration takes place when two different species are grown in close association; the degree of interpenetration increased with the degree of dissimilarities among the species. In one experiment, a legume and nonlegume showed maximum root interpenetration with the explanation apparently being that one species takes up the nutrients made available by the other if the crops are complementary.

Leaf canopy distribution in multiple cropping is extremely important in effective utilization of radiant energy. Williams and Joseph (1970) discussed the pattern of crop canopy development

in mixed cropping systems. Herrera and Harwood (1973) stated that the most successful combinations used in multiple cropping should be crops having widely different leaf canopies, that is, short crops growing under taller ones creating different strata of leaf concentration giving a more efficient utilization of incident light. Chang (1974) indicated that different leaf canopies in multiple cropping would build up a rough canopy architecture allowing good wind turbulence resulting in good distribution of CO_2 for the photosynthetic process and hence would increase the dry matter production. Based on results with crop mixtures involving sorghum, corn and millet, Baker (1975) concluded that the greater the differences between days to maturity of the associated crops the greater was the gain from crop mixing. Lingegouda (1972) suggested that two species of morphologically and physiologically contrasting habit would together be able to exploit the total environment more effectively than monoculture. In India, Reddi and Reddy (1976b) found that peanut grown between two rows of sorghum had the least competitive effects.

An extensive review on component crops in multiple cropping was done by Hart (1974). He reported rubber with corn, sorghum, peanut, soybean, cassava, rice, castor; oil palm with yam, corn, sorghum, peanut, soybean; coffee with banana, sugarcane, cacao, black pepper; cotton with corn, bean, peanut, okra, rice; sugarcane with soybean, peanut, broadbean, onion, cowpea, mungbean, sweet potato, rice, corn, white potato; corn with peanut, cowpea, bean, soybean, millet,

forage grasses; sorghum with soybean, cowpea, bean; rice with mungbean, cowpea, chickpea, sweet potato, soybean; coconut with cacao, pineapple, papaya, various legumes and forage grasses; citrus with grain legumes as component crops in multiple cropping in humid tropics. Arnon (1972) indicated that the popularity of legume intercrops is shown by the fact that 98% of cowpea and the most important legumes in Africa are grown in association with other crops. More than 90% of the bean crop in Colombia is grown in association with maize, potato and other crops (Francis et al., 1976).

Whitty et al. (1978) suggested that sunflower may fit into a multiple cropping system in Florida where February planted sunflower can be followed by soybean, sorghum, cowpea or some other summer planted crops. August planted sunflowers could follow corn, sorghum or other spring planted crops. Willey and Osiru (1973) studied mixtures of maize and bean at different proportions of plant populations. Yields of the mixture were 38% higher than could be achieved by growing the crops separately. It was concluded that the mixtures achieved a greater utilization of environmental resources, particularly solar radiation. At IRRI (1974b) corn and upland rice combinations were consistent in their higher yields, giving a 50% advantage at optimum row spacings and plant populations. Corn and peanut were similarly productive over a range of planting arrangements on small labor-intensive farms. Within the socio-economic framework of small farms with limited power for tillage and little cash for inputs, it was found that growing two or more compatible crops simultaneously in alternate rows is often more profitable.

Intercropping

Intercropping is an increasingly popular practice for producing more food in many areas in the tropics where the pressure on arable land is very high due to increasing population. It is a labor-intensive cropping system generally practiced with the availability of abundant cheap labor and under low level of mechanization (Ruthenberg, 1971). The advantages of such a cropping system as advocated by many authorities are that it: (1) increases food production per unit land area as compared to sole crop (Harwood and Kassam, 1976; Agboola and Fayemi, 1971), (2) reduces pest problems (Litsinger and Moody, 1976; IRRI, 1973) and (3) minimizes the risk of crop failure of monocrop (Andrews and Kassam, 1976). After surveys in Nigeria, Norman (1975) concluded that risk insurance is an important reason why intercropping is practiced. Moreover, the rationale of mixed cropping was evident not only because of increased return but also because of more efficient utilization of labor. In addition, intercropping provides a balanced diet by furnishing diversified food crops. It is particularly advantageous where the growing season is too short for production of two crops in a sequential cropping system. In intercropping, competition between species for available light, water and nutrients must be lower than competition between plants of the same species in single stands (Trenbath, 1976). The yield advantage from intercropping resulted from more efficient use of environment and also from the possibility of increasing the total population pressure of the crops involved (Osiru and Willey, 1972).

In a corn-soybean intercrop study at IRRI (1974a), corn yielded 5.28 t/ha and the soybean yielded 0.85 t/ha. Under identical management, the monoculture yields were 5.52 t/ha for corn and 2.33 t/ha for soybean. The ratios of intercrop yields to monoculture yields were 0.96 for corn and 0.36 for soybean. The sum was 1.32. Total productivity was thus 32% higher and the land equivalent was 1.32 hectares. Traditional intercropping systems with corn using mungbean, soybean, sweet potato, peanut or upland rice were 30 to 60% more productive with good management and up to 100% more productive as various factors became limiting. Studies on plant interrelationships showed that the balance of saturated systems depended on plant populations while productivity was affected by level of management and crop arrangement. Insect relationships in traditional patterns continued to show a high level of natural stability. In another study at IRRI (1975), corn was intercropped at a population of 4 plants/m^2. The corn-alone check was 6 plants/m^2. Sweet potato was 5.3 plants/m^2 both in corn and alone. When intercropped corn was left for more than 35 days, the total number of roots of potato decreased. If corn was left longer than 65 days, little further reduction in root numbers was observed. Thus root number seemed to be determined before 65 days of age, after which few new roots were formed, even after removal of corn. At high levels of nitrogen corn yields were high, but sweet potato remained vegetative with reduced root growth. To test the hypothesis that an intercrop is agronomically more stable than a monoculture of the same crop, corn and peanut were intercropped under simulated plant loss and defoliation at different

times and severity (Liboon et al., 1976). In both crops, damage reduced the yields of the crops for all treatments. Damage to peanuts affected the yield of corn. When corn was slightly damaged and peanuts severely damaged, the corn yield increased slightly. At all growth stages severe damage to corn increased peanut yields significantly. This indicates that the lower canopy had a greater potential to compensate for damage of the upper canopy than had the upper canopy for damage to the lower canopy. Alternating either four 40-inch rows or six 24-inch rows of corn and soybeans resulted in approximately 20% increase in corn yields but a 20% decrease in soybean yields when compared to yields from a similar area of solid plantings of the two crops (Pendleton et al., 1963). The greater part of this difference was due to the grain production from the border rows immediately adjacent to the other crop. This indicates the wisdom of the familiar 2 rows corn and 2 rows of cowpea all over the southern USA in the 1920's and 1930's. Twenty-four inch row spacings were superior to 40-inch row spacings in both crops. Spencer and Russell (1959) reported that at the low corn population (2,700 plants/acre), there was a clear superiority in yields of corn and peanut on the intercropped plots at all peanut populations in the range of 22,400 to 44,800 plants/acre. At the medium corn population (7,500 plants/acre), intercropping greatly increased corn yields at high peanut population. At the high corn population (11,200 plants/acre), there was a geneal reduction in yields of both crops

except for corn grown with a low population of peanut. Intercropping peanut and sorghum was greatly superior to growing pure stands except that the low population of sorghum (11,200 plants/acre) yielded less with a medium population of peanut than in a pure stand.

Intercropping studies under optimum technology indicated substantial (50% or more) yield increases from various combinations of alternate row intercropping as compared to those of separate sole crop culture (Evans, 1969; Andrews, 1972; Harwood, 1973). According to Kung (1975), rice is interplanted with tobacco, jute, sweet potato or soybean; cotton, peanut and soybean are planted between wheat rows. Cotton is intercropped with peanut, sweet potato and corn in India (Varma and Kanke,1969; Tarhalker and Rao, 1975). Tomato, onion, cowpea and chili pepper planted between sugarcane rows is also a common practice in India (Randhawa, 1976; Dayanand and Goswami, 1976). In Taiwan, Shia and Pao (1965) indicated that the short-vined sweet potato variety Tainung 57 had the least effect on yields from interplanted sugarcane, gave fairly high tuber yields and was recommended for intercropping systems.

Grain yield of oats grown alone was higher than when intercropped with soybeans (Brown and Graffis, 1976) in Illinois. On the other hand, Dalal (1977) reported reduced soybean yield when intercropped in corn as compared to sole crop. Experiments in Punjab, India (Narang et al., 1969), showed that the best method of intercropping is soybean in alternate rows with corn planted at 30 x 60 cm. The total yield of corn and soybean in 1965 and 1966 was 2.47 and 3.33 t/ha, while corn alone yielded 1.95 and 2.93 t/ha, respectively.

The competition between corn and intercrops was essentially the competition for nitrogen and water (Kurtz et al., 1952). A sufficiency of nitrogen and water, however, did not completely eliminate the competition. Evans (1969) showed that in two areas of contrasting soil fertility levels and different rainfall, intercropping of corn or sorghum with peanut resulted in higher average yield/ha than when those crops were grown in pure stands for two years. As the corn population was decreased, the reduction in corn yield was greatest in the absence of peanut. Saxena and Yadav (1975) pointed out that intercropping pigeonpea with sorghum, corn and pearlmillet has generally resulted in reduction in pigeonpea yield. Palada and Harwood (1974) concluded that if fertilizer responsive cultivars with proper maturity are used, the corn-rice intercrop combination will respond to high levels of nitrogen.

Relay intercropping systems can be an effective way to increase yield (Dalrymple, 1971) and have been extensively recommended (Nayasaland, 1948; Hayward, 1969). Relay intercropping permits fuller use of solar radiation and available water by planting a second crop before the first one is harvested. It is likely that plants of different species relay intercropped can make better use of the natural resources. Examples of relay intercropping systems have included interplanting sorghum with cotton (Tarhalker and Rao, 1975) or with corn (Varma and Kanke, 1969; Nigeria, 1955). Relay systems involving rice as a principal crop have also been recommended (Sung and Wu, 1966; Bradfield, 1972). Gallaher (1975) pointed out

that barley and corn yields in Georgia were 50 and 25% less, respectively, in relay intercropping as compared to double cropping.

Soybeans in Double Cropping Systems

The importance of a legume component in the cropping system has been universally emphasized. Soybean occupies the number one position in terms of world oil supplies. As a member of the legume family and topmost oil producer it is an important component in double cropping systems. Soybeans are highly photoperiodic. Thurlow (1971a) reported that soybeans grow vegetatively until days shorten to a length critical for each variety, then vegetative growth stops and fruiting begins. For each variety the day length required to initiate flowering is specific. Because of the photoperiod differences, varieties have been divided into 9 maturity groups with 00 designating early maturing varieties and VIII designating late maturing varieties. The groups V, VI, VII and VIII are adapted in the southern states of the USA. The average critical day length in group VII is 14.5 hours. Varieties in group V and VI have a longer critical day length, thus flower in mid-summer, and are earlier maturing than group VII; group VIII varieties have a shorter critical day length and are later maturing than those of group VII. When planted late, mid- and late-season varieties (group VII and VIII) grow longer and yield more than earlier maturing varieties. According to Hinson (1974) the maximum photoperiod difference of 1.5 hours caused differences of 45 days from emergence to maturity, 21 days from emergence to flower, 33 days from flowering to maturity and 14 inches of plant height. From a series of experiments, Whigham (1975) reported that a longer

season permitted taller growth of plants which resulted in more vegetative growth and the plants were capable of supporting more seeds during the reproductive stage because of greater photosynthetic leaf area. Therefore, more flowers were initiated or fewer aborted.

Many authors indicated the advantages of soybean as a member in double cropping systems. Having soybean in the Minnesota double cropping system, Pond (1950) reported that soybean could be planted later than many other crops, the labor requirement was low and came at a time when competition was not so great and it improved the physical conditions of the soil. Peters et al. (1971) observed better use of labor and equipment and lower break-even yields for each crop in a double cropping study with corn followed by soybean.

In the eastern United States the most popular double cropping system is wheat or barley harvested for grain followed by soybeans for grain (Lewis and Phillips, 1976). Corn and sorghum for grain and silage and soybeans for grain have been successfully double crop planted in June following winter barley harvested in eastern Virginia (Camper et al., 1972). When the June plantings were harvested for grain, corn produced the greatest net dollar returns. However, when planted in July soybeans were more dependable for grain than corn or sorghum. Selected cultivars of soybeans were suggested for use as a second crop after sorghum and corn under irrigation in north and west Florida (Guilarte et al., 1975). In a three-year Alabama study, soybean grown as a single crop yielded an average of 2,124 kg/ha. But soybean grown in a double cropping system following wheat harvested for grain (2,533 kg/ha) yielded an average of 1,808

kg/ha (Rogers et al., 1971). In a sequential double cropping experiment in Minnesota, corn yields following soybeans were higher than corn yields following oats because of the residual nitrogen contributed by soybeans (Schmid et al., 1959). Soybeans are grown in double or triple cropping systems with rice as a major crop in Taiwan (ASPAC, 1974) and Thailand (Anonymous, 1974). Harwood and Price (1976) stated that for the puddled, heavy clay soils following rice, where tillage is difficult or impossible, the soybean is probably the best adapted crop in Monsoon Asia.

Based on surveys made in several states, Elliott (1977) concluded: "whatever system is used to speed up soybean planting in a double cropping program, two factors are critical: management and moisture." Owens (1974) projected several economic and physiological reasons for double cropping of small grain crops (wheat, barley and rye) followed by soybeans in Ohio, Virginia, North Carolina, Missouri and Illinois. Peele et al. (1974), working on double cropping of soybean, reported slight differences in soybean yields for the different methods and cultivars used, but in general it seemed that double cropping small grain-soybean should be profitable in South Carolina.

The effect of temperature and light intensities on soybean growth was studied by Hofstra (1973). The maximum increase in leaf area occurred at 27 C at early stages of growth. At later stages of development, the difference in growth rate due to temperature diminished. Either there was acclimatization to temperature with time, or something other than temperature became rate-limiting

under these conditions. He obtained a maximum rate of photosynthesis in soybean at around 35 C. The partitioning of assimilates changed with temperature, with a high percentage going to auxiliary growth at lower temperature and almost none at higher temperature. Although the percentage of dry weight present in leaf blade was constant across temperatures, specific weight varied more or less inversely with the rate of leaf area increase. These results suggest that all assimilates are used in production of new tissues at higher temperature (27-30 C), whereas at lower temperatures assimilates may be in excess of what the plant can use for new leaf production on the main stem.

An experiment was conducted by Camper and Smith (1958) in Virginia with two varieties (S-100 and Ogden) planted on May 20, June 5, June 20 and July 5 at 12, 24 and 30 inches row spacings and at the rate of 6, 12 and 18 seeds per foot of row. He found that the maturity date was reduced approximately one day for each two days later planting of S-100 and one day for each 2.5 days later planting of Ogden, but the amount of delay varied from year-to-year and also from one planting to another. Seed size was not affected by date of planting, rate of planting or row width except the last planting of Ogden was smaller than for other seeding dates. The July seeding produced a lower quality seed than was produced for earlier seedings and the oil content was lower in the last planting in both varieties. Working with late-planted soybean, Rezende (1978) obtained the highest seed yields at the highest plant population and narrowest row width.

Experiments carried out by Jeffers et al. (1973) reported that yields of soybeans planted at different dates decreased with later plantings in both irrigated and unirrigated soil. Plants of commonly grown soybean cultivars planted later than the recommended dates of May 15 to June 15 tend to be short, produce seed pods close to the ground, have a short life cycle and often yield poorly (Akhanda et al., 1976). The above reviews indicate that appropriate cultivars of soybeans need to be developed so that they can overcome or minimize the negative effects of late planting.

Plant Density in Sorghum

Sorghum grain is a basic food in many parts of Africa and Asia. It is also a principal source of alcoholic beverages in many countries (Martin, 1970). Sorghum, sometimes referred to as the great millet, is one of the most important crops in Asia and Oceania because of its great range of adaptation, productivity of both grain and fodder, and its many other uses. It is second to rice among the hot weather cereals throughout much of southern and eastern Asia (Rachie, 1970) and eastern Africa (Doggett et al., 1970) which is known to be its original homeland. Sorghum has high resistance to desiccation, an extensive fibrous root system, an effective transpiration rate and several xerophytic leaf characteristics that retard water loss from the plant. Because of its xerophytic nature, sorghum is an important grain crop in the semi-arid tropics. Kramer and Ross (1970) pointed out that the performance of sorghum under adverse conditions gives it a value above the cash value of the grain and helps to maintain a more stable agricultural system.

Sorghum can produce a satisfactory yield in a wide range of plant densities because it has an amazing capacity to sucker at low populations (Ross, 1977). Effects of row spacings and plant populations on yield and yield component associations were examined in Iowa by Atkins and Martinez (1971) using 12 cultivars of grain sorghum. Grain yields and number of seed/head were highest in 30-inch row width followed by 40- and then 20-inch. Weight/100 seeds was highest in 40-inch row spacing. Seeds/head and heads/plant were greater at lower population though the maximum grain yield was obtained from the highest population. In India, Prabhakar et al. (1972) found that the intrarow spacing of 15 cm with 37.5 cm interrow spacing was superior to other treatments. The increase in grain yield with 37.5 cm X 15 cm spacing was 72% better than the spacing of 37.5 X 30 cm. Even though the length of panicle was longest in the latter, the grain production was less. A consistently significant increase in grain yield with the decrease in row spacing from 60 to 30 cm was observed by Upadhyay and Sreenivas (1966). They also obtained a significant increase in sorghum yield with the decrease in plant to plant spacing from 22.5 to 7.5 cm. Atkins et al. (1968) evaluated the performance of two short hybrids at different row widths and within-row plant populations. Correlation coefficients of 0.28 and 0.29 were obtained in two years for the association of seeds/head with grain yield. Coefficients for head/plant and seed size with yield were also appreciably smaller for the short hybrids than those reported for tall hybrids. Coefficients for seed/head with grain yield in case of tall varieties ranged from 0.51 to 0.72.

Prine (1969) suggested that grain sorghum should be planted in narrower rows than the common 36-inch width. Grain sorghum yields were not significantly affected by plant population from one to four plant per square foot during three seasons in his experiments. But higher plant population recorded significantly higher grain yield in a study conducted by Raghunatha (1977). In his experiment the differences in yield components among stand geometries were not significant though triangular and square plantings were slightly more productive than rectangular planting. Significant responses to plant population were found in 4 of the 9 experiments in India (Singh et al., 1972). The low population, 9 plants/m^2, was always the lowest and 13.5 plants/m^2 was equal to or better than the highest plant population at 3 of 4 locations. The average grain yields for 9, 13.5 and 27 plants/m^2 were 2,980, 3,530 and 3,690 kg/ha. On the contrary to the above two experiments, Rao et al. (1976a) obtained lowest grain yield from the highest population as a result of decrease in panicle weight and increased lodging. He explained that the higher populations enhanced maturity and decreased the grain filling period, resulting in low seed weight, possibly because of acute plant competition for moisture and nutrients. However, Reddy and Murty (1977) did not detect any significant difference in yield in a range of plant population treatments from 45 to 180 thousand plants/ha. The interaction effect between population levels and four entries was also not significant. In an experiment conducted with varieties of grain sorghum at Hague near Gainesville, Taylor-Evans brand Bird-A-Boo II produced 4,570 kg of

grain per hectare (Green, 1973). He also found that the increased tannin content increased resistance to birds but decreased the digestibility (IVOMD).

Plant density is an important factor if sorghum is to grow as a component crop in intercropping. Increasing plant population drastically increased the leaf area index (LAI) resulting in increased shading as observed by many authors (Mauco, 1977; Akhanda et al., 1978). Duncan (1971) suggested that if the plant canopy is expected to be below an LAI of 3.0, leaf angles have little significance but will be quite meaningful over 5.0. Therefore, lower plant density might be desirable in sorghum if some other compatible crops are grown as intercrops in sorghum. Finlay (1974b) stated that sole cropping of sorghum in northern Nigeria resulted in a dramatic yield depression from the first to the second crop, after which yield declined gradually. He suggested that intercropping or mixed cropping, particularly with legumes, can avoid this reduction. Sarma et al. (1970) successfully intercropped Bengal gram (Cicer arietinum) and safflower with sorghum. Bengal gram or safflower, planted between the rows of sorghum, developed while the sorghum was small. Considering time saving and low cost of production, ratoon cropping in sorghum has been suggested by many authors (Escalada and Plucknett, 1975, 1977). In northern India, there were fewer problems with insects and weed with ratoon crop of sorghum than with a new crop planting on the same date (Pal and Kaushik, 1969). Among 51 sorghum cultivars, the highest grain

yield of ratoon crop was 46% of the first crop with an average yield of 26% as reported by Green (1977c). In a double cropping system in Florida, Guilarte et al. (1975) suggested that grain sorghum as a first crop should be planted in late March. They also indicated that seed yields of both first and second crops will be improved if higher plant population and narrower row spacings are used than when crops are grown in the conventional one crop system.

Plant Density in Sunflowers

World sunflower (*Helianthus annuus* L.) production has expanded during the last decade to become the second leading oilseed crop in the world, surpassed only by soybean (Kromer, 1974). Sunflower is considered to be an efficient user of radiation energy because of its high phototropic nature and its comparative superiority to other oilseed crops in terms of oil composition and yield (Robertson, (1975). It has a peculiar process called 'nutation' which keeps the head facing the sun during the day until anthesis. Leaves can also orient towards the incoming radiation by the movement of leaf petioles.

Number of heads per hectare, number of seeds per head and average seed weight are the three yield components and product of these is yield per hectare. Number of heads per unit area is dependent on plant population and spacing. Disagreement as to optimum plant population is a common occurrence within a region as well as among countries of the world. With the increasing plant population, seed yields increased (Massey, 1971; Lascu and Chiorescu, 1976), decreased (Lehman, et al., 1973; Longo and Restuccia, 1975) or did

not differ (Johnson and Marchant, 1973; Vijayalakshmi et al., 1975). The effect of different row widths on seed yield was similar and in 13 out of 14 trials there was a noticeable trend for oil percentage to increase with population (Robinson et al., 1976). On the contrary, Alessi et al. (1977) obtained highest oil for the lowest population from a range of 25 to 100 plants/m^2 in a 30- and 90-cm row widths. Henry (1968) reported that 'Armavirec' and 'Peredovik' cultivars yielded best at the lowest seeding rates which also resulted in the best oil yields per unit area. In his study the percentage of oil increased slightly with increasing seeding rates. It was also observed that increasing the number of plants per acre tended to delay flowering slightly but hastened maturity by up to four days. Lodging also increased with the higher populations. In an experiment in Bangladesh (Majid et al., 1976), maximum percentage of oil in kernel and oil per unit area for a local sunflower variety, H-67-6, was obtained at row spacings of 24 inches, the highest percentage of protein in kernel at 36 inches and protein per unit area at 18 inches.

Due to intraspecific competition, both diameter of head and 100-seed weight decreased with the increase in plant population of sunflower. Karami (1977) reported that closer plant spacing resulting in higher plant density reduced the diameter of head and 100-seed weight in 'Record' cultivar of sunflower in Iran. The seed yield had a significant positive correlation with diameter of head and also with weight of seed per head (Rao et al., 1976b) in

a study in India. In another study, Singh et al. (1977) found high variability among eight cultivars for seed yields, 100-seed weight, plant height and seed filling. Yield was positively correlated with plant height, head diameter and 100-seed weight at both genotypic and phenotypic levels.

Time of planting was found to influence the growth and yield of sunflower. In a field trial in West Bengal (India) Bhattacharya et al. (1975) found that seed yields were 1.93 and 1.87 t/ha and oil yields were 726 and 768 kg/ha with sowing on 28 November and 12 December, respectively. It was also found that delay in sowing after 12 December decreased yields due to high temperature and low relative humidity during active vegetative growth, floral development and maturation stages. Effect of date of planting and the row spacing on sunflower was studied by Lopez in 1972. He obtained 1,220, 1,374 and 1,497 GDD required to complete the life cycle (planting to maturity), respectively, for March 4, March 19 and April 3 plantings.

In subtropical regions including the lower southern United States, a sunflower can be a profitable first crop in a warm season double cropping system. It can be an important crop compatible in multiple cropping systems in the tropics. Results indicated that sunflower can be competitive with corn in terms of dry matter production when planted in a double cropping system (Sheaffer et al. (1977). Moreover, sunflower can stand 28 to 32 F from seeding

to flowering stage (Killinger and Whitty, 1972). Thus it offers special advantage in that it can be planted in late winter or early spring and save time where the warm growing season is limited by low temperature.

The inconsistent effect of row widths and plant populations on sunflower yield at different locations suggest that it should be evaluated for particular cultivars, areas and climatic conditions to attain optimum yield.

MATERIALS AND METHODS

The experiments were conducted on Arredondo fine sand at the main Agronomy Research Farm at the University of Florida, Gainesville. The field work was carried out during the summer and fall of 1976 and spring, summer and fall seasons of 1977. The crop species used as test materials in different experiments were soybean (*Glycine max* (L.) Merr.), corn (*Zea mays* L.), sorghum (*Sorghum bicolor* L. Moench), sunflower (*Helianthus annuus* L.), sweet potato (*Ipomoea batatas* (L.) Lam.), peanut (*Arachis hypogaea* L.) and pigeonpea (*Cajanus cajan* L. Druce). Most of the planting materials used were from the previous harvest of the crops at the Agronomy Research Farm except sunflower and sweet potato which were received from the National Cottonseed Products Association, Inc., Memphis, Tennessee, and a certified potato plant producer near Valdosta, Georgia, respectively.

Experiment 1. Evaluating Soybean Cultivars for Use as a Second Crop in Warm Season Double Cropping Systems

In 1976, 129 soybean cultivars and breeding lines as indicated in Appendix Table 1 were used as test materials. Based on their performance, 84 (Appendix Table 2) out of 129 lines were selected to repeat the investigation in 1977. The land used in these studies

was planted to corn which was plowed down prior to planting soybean in both years. Planting was made on two dates each year. The first planting in 1976 was made on July 20 followed by the second planting on August 6. The first and second plantings in the next year were, respectively, on July 15 and August 3. The second planting was made in similarly managed adjacent sites in both years. Randomized complete block designs with three replications were used in all cases. The plot size was four rows 41 cm apart and four meters long in 1976 while only the row length was changed to six meters in the next year. Twenty-one seeds were planted per meter of row.

The field was fertilized with 780 kg/ha of 4-8-16 (N-P_2O_5-K_2O) mixed fertilizer at corn planting in both years. In addition, 500 kg/ha of 0-10-20 (N-P_2O_5-K_2O) fertilizer was applied before planting soybean in 1976 but no additional fertilizer was used in 1977. The plots were sprinkler irrigated whenever necessary during dry periods. LASSO (43% EC) and PREMERGE (51% EC) were used for weed control and LANNATE (24% EC) for controlling insects. The plots were hand hoed and cultivated at 15 and 25 days, respectively, after emergence to control weeds.

The flowering and maturity characteristics were determined by visual observation in each plot every other day. The dates each entry began flowering, pod filling, stopped flowering and reached physiological maturity were recorded. Beginning of flowering was

recorded on the date when more than 20% of the plants were in bloom and end of flowering when 80% of the plants had no fresh flowers. The beginning of pod filling and physiological maturity dates were determined following the methods suggested by Fehr et al. (1971). The beginning of pod filling (R_5) date was recorded on the day when the accumulation of milky photosynthate in pods at one of the four uppermost nodes with a completely unfolded leaf was felt by squeezing with the fingers. The physiological maturity (R_7) date was the day when pods started yellowing and more than 50% leaves were yellow in a plot. The "ready for harvest" date was recorded when the pods and plants in a plot became completely dry and the leaves dropped to the ground, though the plot was not harvested on that date. The length of pod filling period and life cycle were the days, respectively, from beginning of pod filling and planting to physiological maturity.

Plant height was the average stem length from the base to the tip of the stem. Height of lowest pod was the average distance from the soil surface to the bottom of the lowest pods on standing plants at maturity. Seed yield was determined by harvesting the two middle rows in each plot after border plants were removed on each row end. The seed yield per plot was recorded at 12% moisture content and then calculated on a kg/ha basis.

The growing degree days (GDD) were calculated by subtracting the base temperature of 50 F (according to Martin and Leonard, 1967a) from the daily average temperature for each day from planting

to physiological maturity and then adding them together. A similar method was also used by Major et al. (1975a) for predicting soybean development. The GDD for various development phases such as flowering and pod filling periods was determined by computing and adding the "degree days" for the pertinent periods.

Experiment 2. Effect of Plant Population and Row Width on the Yield and Yield Components of Sorghum

Two grain sorghum hybrids, Taylor-Evans brand 'Bird-A-Boo II' and Pioneer brand 'B-815', were planted at three row spacings of 41, 61 and 91 cm and at three populations of 20, 30 and 40 plants/m^2 corresponding to 200,000, 300,000 and 400,000 plants/ha on March 22, 1977. The design of the experiment was a split-split plot with cultivars as main-plot, row-widths as subplot and plant populations as sub-subplot. There were four replications and the unit sub-subplot size was 4.27 x 1.83 m. Each unit plot had four, three and two rows, respectively, at 41, 61 and 91 cm spacings. Twenty percent more seed than required for the specified populations was planted and the plant counts after flowering indicated that the stands were very close to the desired populations.

The field was fertilizer with 500 kg/ha of 10-10-10 (N-P_2O_5-K_2O) mixed fertilizer before planting. Forty days after emergence, 200 kg/ha of $Ca(NH_4)NO_3$ which provided 50 kg/ha N was broadcast and followed by irrigation with a water-gun. Irrigation was given whenever necessary during the dry periods of the growing season. Interrow spaces were cultivated twice at 20 and 35 days, respectively, after

emergence for controlling weeds. However, the weed control was not complete. FURADAN (40.64% flowable), a systematic insecticide was incorporated at 5 l/ha into the soil one week before planting. In addition, LANNATE (24% EC) at 2.5 l/ha was sprayed once before flowering for insect control.

Plant height was the average distance from the soil surface to the tip of the panicle, and the panicle length was the average from the base to the tip of the panicle. Leaf area of all the leaves of three randomly selected plants per plot was measured with automatic area meter (Model AAM-5, Hyashi Denko Co. Ltd., Japan) to find out the average leaf area per plant. Leaf area index (LAI) was then calculated by dividing the average leaf area of the plant with the land area it occupied in that plot. In computing GDD, a base temperature of 60 F (according to Leonard and Martin, 1967b) was deducted from the daily mean temperature.

Grain yield was determined by harvesting one and two middle rows, respectively, from three- and four-row plots and both rows from two-row plots after the border plants on each row end were removed. Grain samples were dried to a constant weight before weighing and then converted to kg/ha.

Experiment 3. Effect of Plant Population and Row Width on the Yield and Yield Components of Sunflowers

Sunflower cultivars planted in this experiment were Interstate 891, Pacific Oilseeds Sun-Hi 304 and Cargill 204. The row widths and plant populations used were, respectively, 41, 61 and 91 cm and

4, 6 and 8 plants/m^2 equivalent to 40,000, 60,000 and 80,000 plants/ha. The experimental design, plot size, number of rows in plots and number of replications were the same as in experiment 2. More seeds than required were planted on February 17. At the 3-4 leaf stage, extra seedlings were removed to maintain exact plant populations according to the population treatments.

At land preparation, 500 kg/ha of 10-10-10 (N-P_2O_5-K_2O) mixed fertilizer was incorporated into the soil along with 2 kg/ha of FURADAN (40.64% flowable) one week before planting. Afterwards 300 kg/ha of 15-0-15 (N-P_2O_5-K_2O) fertilizer containing 45 kg N and 45 kg K_2O and 200 kg/ha of ammonium nitrate having 50 kg N were top-dressed, respectively, 40 and 50 days after emergence and followed by irrigation by water-gun. The plots were hand hoed and cultivated at 10 and 20 days, respectively, after emergence. LANNATE (24% EC) at 2.5 l/ha was sprayed a few days before flowering to control insects. For protecting grain from bird damage, one kg (a.i.)/ha of MESURAL (75% WP) was sprayed two weeks before harvest.

The variables measured in this study were diameter of stem after flowering, plant height at maturity, LAI, diameter of head, 100-seed weight and seed yield. Diameter of stem above 12th leaf was measured with a slide caliper. Three randomly selected plants per plot were measured and the average was recorded. Diameter of head was the average of three random heads per plot taken before harvest.

The LAI was determined by using the following regression equation developed for Taro (Colocasia esculenta) by Bourke et al. (1976):

$$Y = 8.61 + 1.42165X^2$$

where, Y = leaf area in cm^2

X = AA' in cm

AA' = distance (cm) from the base of the leaf blade (the point at the base where the midrib and veins join together and petiole join the leaf blade) to the tip of the leaf.

The distance AA' of all the leaves of three randomly selected plants per plot was measured and the average was calculated. Leaf area of the average leaf was determined by fitting the average AA' into the above regression equation. The average leaf area thus determined was multiplied by the average number of leaves/plant in each plot to compute the total leaf area of the average plant in cm^2. Dividing the total leaf area of the plant by the land area occupied by it, the LAI was obtained. For calculating GGD, a base temperature of 32 F (according to Keefer et al., 1976) was deducted from the daily mean temperature.

Seed yield was determined by harvesting one and two central rows, respectively, from three- and four-row plots and both rows from two-row plots. The border plants on both ends of yield rows were eliminated prior to harvest to avoid border effects. The seeds were dried to a constant moisture level (12%), weighed and converted to kg/ha. One hundred random seeds were taken from each plot to measure 100-seed weight. Composite seed samples out of different row widths

and plant populations of each cultivar were analyzed by the Agricultural Research Center, USDA, Athens, Georgia, to measure oil contents along with fatty acid components.

Experiment 4. Intercropping Peanut, Pigeonpea and Sweet Potato in Corn

Florunner, Dixie Runner and Early Bunch peanut, Norman pigeonpea, Alabama Nugget (okra leaf) and Red Jewel (common leaf) sweet potato were interplanted in Pioneer 3780 (early-maturing), Pioneer 3369A (medium-maturing) and McNair 508 (late-maturing) corn. The corn population treatments were 2.4, 4.8 and 7.2 plants/m^2 corresponding to 25,000, 50,000 and 75,000 plants/ha. The experiment was laid out in a randomized complete block design with four replications. The treatment (T) combinations are shown in a tabular form as follows:

Corn hybrid	Corn population (plants/m^2)	Intercrop		Treatment combination (T)
		Crop	Row spacing (cm)	
Pioneer 3780 (early)	2.4	Florunner peanut	91	T_1
	4.8	None		T_2
		Florunner peanut	91	T_3
		Dixie Runner peanut	91	T_4
		Early Bunch peanut	91	T_5
		Alabama Nugget sweet potato	91	T_6
		Red Jewel sweet potato	91	T_7
	7.2	Florunner peanut	91	T_8

Corn hybrid	Corn population (plants/m^2)	Intercrop Crop	Row spacing (cm)	Treatment combination (T)
Pioneer 3369A (medium)	2.4	Florunner peanut		T_9
	4.8	None		T_{10}
		Florunner peanut	91	T_{12}
		Florunner peanut	46	T_{13}
		Dixie Runner peanut	91	T_{14}
		Dixie Runner peanut	46	T_{15}
		Early Bunch peanut	91	T_{16}
		Early Bunch peanut	46	T_{16}
		Alabama Nugget sweet potato	91	T_{17}
		Red Jewel sweet potato	91	T_{18}
		Norman pigeonpea	91	T_{19}
	7.2	Florunner peanut	91	T_{20}
McNair 508 (late)	2.4	Florunner peanut	91	T_{21}
	4.8	None		T_{22}
		Florunner peanut	91	T_{23}
	7.2	Florunner peanut	91	T_{24}
		Pure stand		
None	None	Florunner peanut	91	T_{25}
		Florunner peanut	46	T_{26}
		Dixie Runner peanut	91	T_{27}
		Dixie Runner peanut	46	T_{28}

Corn hybrid	Corn population (plants/m^2)	Intercrop: Crop	Intercrop: Row spacing (cm)	Treatment combi-nation(T)
None	None	Early Bunch peanut	91	T_{29}
		Early Bunch peanut	46	T_{30}
		Alabama Nugget sweet potato	91	T_{31}
		Red Jewel sweet potato	91	T_{32}

Corn hybrids were planted in rows 91 cm apart on March 11 at a higher seed rate than required. The entire experimental area including the spaces for pure stands of intercrop species was planted in order to give uniform treatment to the whole area. At the 3-4 leaf stage, extra seedlings were hand-pulled to maintain the exact corn populations according to the treatments. The unit plot size was four corn rows 91 cm apart and six meters long. Two days before planting intercrops, plants from four corn rows at regular intervals along the field were removed to create strips of open space for planting intercrop species as pure stands.

Peanut and pigeonpea were planted between corn rows at 14 and 12 seeds/m row, respectively, on April 20. There were three rows of peanuts and pigeonpea 91 cm apart in an unit plot of corn hybrid. All three peanut cultivars were also planted in double rows 46 cm apart between corn rows in selected treatments and which gave six-row plots of intercropped peanut in corn. At the same time, all

three cultivars were planted at 91 and 46 cm rows in identical plots as pure stand in the open spaces created by removing corn plants. Similarly, Alabama Nugget and Red Jewel sweet potato cultivars were planted in rows 91 cm apart at the rate of four draws/m row on April 25 both inside the corn as intercrops and outside as pure stand. Sweet potato draws were planted on manually-raised beds about 10 cm high. The intercrops were planted 40 to 45 days after planting corn and at a stage when early-, medium- and late-maturing corn hybrids were, respectively, 140, 130 and 120 cm tall.

Before planting, the field was fertilized with 800 kg/ha of 4-8-16 ($N-P_2O_5-K_2O$) mixed fertilizer plus 16 kg/ha of fritted trace elements (FTE 503). At the same time, 5 l/ha of FURADAN (40.64% flowable) was incorporated into the soil for controlling soil borne insects. Thirty-five days after corn planting, 400 kg/ha of NH_4NO_3 (33.5% N) and 200 kg/ha of 15-0-12.3 ($N-P_2O_5-K_2O$) fertilizer were sidedressed and followed by sprinkler irrigation. One week before planting intercrops, 5 l/ha of LASSO (43% EC) was sprayed in all the plots except those for sweet potato. Fifteen kg/ha of MALATHION (5% P) was dusted on corn 32 days after planting. Spider mites (Tetranychus sp.) and fungus diseases were observed to be serious problems for intercrops. As a control measure, 1.5 kg/ha of KELTHANE (85.5% EC) and 0.75 kg/ha of BENLATE (50% WP) were mixed and sprayed 35 days after intercrop planting and repeated twice at seven-day intervals. It was extremely difficult to reach the intercrops under the thick corn canopy with spray materials by the mechanized commercial sprayer.

The interrow spaces were cultivated once 25 days after corn planting followed by a hand weeding. But weed competition was serious for the intercrops at the later stages of growth though the effect on corn was considered to be small. The whole growing season was abnormally dry. The plots were irrigated regularly once a week by sprinkler irrigation and supplied about an acre-inch of water each time until the late-maturing corn reached black layer stage. Afterwards, irrigation was not necessary for the intercrops since there were frequent rains. At the milk stage of corn, the corn ears of all yield rows were covered by paper bags to protect them from bird damage. After corn harvest the stalks were left standing in the field until all the intercrops were harvested.

Variables measured in this study were plant height, number of ears per plant, LAI and grain yield in corn, dry matter production in pigeonpea, pod yield in peanut and root yield in sweet potato. Plant height was the average distance from soil surface to the tip of tassel of corn at maturity. Number of ears per plant was obtained by dividing the total number of ears with the total number of plants in the harvested area. Leaf surface area (leaf length x maximum width x 0.75 according to Montgomery, 1911) of all the leaves of three randomly selected plants per plot was measured to find out the average leaf area per plant. LAI was calculated by dividing the average leaf area per plant by the land area of the plant in each plot. GDD for each day of corn life cycle (planting to black

layer development) was computed using the following formula as used by Prine et al. (1975):

$$GDD = \frac{\text{Max Temp. F} + \text{Min Temp. F}}{2} - 50$$

where temperature < 50 F = 50 F and > 86 F = 86 F.

Grain yield of corn was determined by harvesting 4.88 m sections of the central two rows after eliminating border plants on each row end. The harvested ears were dried to a constant weight (12% moisture), shelled and weighed. In case of intercrops, 4.88 m sections from the central row out of three plot rows 91 cm apart were harvested. In case of 46 cm spacings, central two rows out of six were harvested to determine yield. Likewise, 4.88 m sections of two and three rows were harvested, respectively, from 91 and 46 cm row-spacings of intercrops grown as pure stand. Peanut pods were dried to a constant weight before recording plot yield. Pigeonpea plants were cut at the base and dried in a forage dryer to determine dry matter production. Sweet potato roots were cured at 50 C in a seed dryer for 72 hours, weighed and converted into kg/ha.

Analysis of variance, General Linear Model and Correlation Analysis of data on grain yields and yield components were carried out by computer to find out the differences and relationships. Duncan Multiple Range Tests were used to compare the treatment means.

RESULTS AND DISCUSSION

Experiment 1. Evaluating Soybean Cultivars for Use as a Second Crop in Warm Season Double Cropping Systems

The dates of beginning and end of flowering, beginning of pod filling (R_5), physiological maturity (R_7) and ready for harvest for 1976 and 1977 are presented respectively in Appendix Tables 1 and 2. Ranges in various measurements at two planting dates in both years are given in Table 1. In the first planting (July 20) of 1976, the beginning of flowering ranged from August 26 to September 15; the end of flowering ranged from September 15 to October 10; R_5 ranged from September 8 to October 3 and the cultivars matured (R_7) between October 16 and November 13. In the second planting (August 6) of 1976, the above ranges were, respectively, from September 5 to 25, September 27 to October 18, September 18 to October 14 and October 28 to November 20. In 1977, the beginning of flowering, end of flowering, beginning of pod filling and date of physiological maturity ranged, respectively, from August 26 to September 12, September 28 to October 12, September 12 to 28 and October 23 to November 5 for first planting (July 15). In the second planting of 1977, the above ranges were, respectively, September 5 to 22, October 3 to 24, September 21 to October 10 and October 26 to November 16.

Table 1. Ranges in various measurements for two planting dates among 129 soybean lines in 1976 and 84 lines in 1977 grown at Gainesville, FL.

Observation or measurements	1976 Ranges among 129 lines		1977 Ranges among 84 lines	
	July 20 planting	August 6 planting	July 15 planting	August 3 planting
Planting to flowering period	37 to 57 days	31 to 50 days	49 to 59 days	30 to 50 days
Flowering period	17 to 30 days	22 to 33 days	29 to 40 days	25 to 35 days
Pod filling period	34 to 52 days	33 to 50 days	36 to 47 days	33 to 41 days
End flowering to physiological maturity	21 to 44 days	18 to 39 days	20 to 33 days	18 to 29 days
Life cycle	88 to 116 days	83 to 106 days	99 to 113 days	84 to 105 days
Plant heights	27 to 112 cm	24 to 94 cm	53 to 105 cm	24 to 64 cm
Lowest pod heights	0 to 33 cm	0 to 30 cm	9 to 26 cm	0 to 13 cm
Physiological maturity (R_7)	Oct. 16 to Nov. 13	Oct. 28 to Nov. 20*	Oct. 23 to Nov. 5	Oct. 26 to Nov. 16
Seed yields	Up to 4500 kg/ha	Up to 3100 kg/ha	Up to 3600 kg/ha	Up to 2400 kg/ha

*Freeze affected late maturing lines

Date of beginning of flowering in soybean after emergence is known to be controlled mostly by the hereditary character and partly by day length and temperature. Hanh (1965) found that soybean plants continue to make vegetative growth when day lengths are long, and, under field conditions, flowering begins when the day length falls below a critical length specific for each cultivar. Flowering time and maturity date showed comparatively high heritabilities of 75.6 and 75.3%, respectively (Weber and Moorthy, 1952). Day length has been recognized as highly important in soybeans for more than 50 years. Howell (1963) reported that soybean plants continue to make vegetative growth when day lengths are longer than critical and with 12 hours of day light, nearly all varieties began flowering 21 to 28 days after emergence. These discussions give sufficient reasons why the planting to flowering period, on an average, was more than a week shorter in the second planting than in the first planting in both years. Moreover, Criswell and Hume (1972) reported that flowering of late-maturing soybean cultivars was more sensitive to day length than flowering of early cultivars.

The cultivars which will reach R_7 earlier than November 10 are likely to escape early fall frost damage in Florida as the minimum temperature of -2 C and 0 C (28 F and 32 F) occurred by November 10 in 2 and 14% of the years over a 30-year period at Gainesville (Johnson, 1970). Therefore, late planted soybeans which mature during the first week of November are likely to escape frost damage in subtropical regions. In the first and second plantings in 1976, respectively, 122 and 110 out of 129 lines physiologically matured

before November 10. In 1977, all cultivars except the Jupiter selection (reached R_7 on November 16) in the second planting reached physiological maturity within the first week of November.

Days from planting to flowering, length of flowering and pod filling periods, from end of flowering to R_7, from R_7 to harvest and the length of life cycle, respectively for 1976 and 1977, are given in Appendix Tables 3 and 4. The ranges in various measurements at two planting dates in both years are given in Table 1 and the correlation coefficients between various measurements for both dates of planting in 1977 are recorded in Table 2.

The period from planting to flowering among cultivars in the first and second plantings ranged, respectively, from 37 to 57 and 31 to 50 in 1976 and 42 to 59 and 30 to 50 days in 1977. This period was considered to be the most important factor affecting the length of life cycle of different lines at different planting dates. It was more than a week shorter in the second planting as compared to the first probably due to the difference in physiological processes influenced by changes in photoperiod and temperature. Osler and Cartter (1954) also found that the varietal maturity differential response to planting dates occurred primarily during the period from planting to flowering. This period was positively correlated to the length of life cycle ('r' values from 0.61** to 0.63**), plant height at maturity ('r' values from 0.40** to 0.41**) and bottom pod height ('r' values from 0.40** to 0.54**) and negatively related to the length of pod filling period ('r' = -0.52**). This indicates that the longer the period from the planting to flowering the longer the

Table 2. Correlation coefficients between various measurements on soybean planted on two dates at Gainesville, FL in 1977.

Variables	Planting to flowering (days)	Length of flowering period (days)	Length of pod filling period (days)	Length of life cycle (days)	Plant height at flowering (cm)	Plant height at maturity (cm)	Bottom seed height (cm)
Planting to flowering (days)	1.00[1/] 1.00[2/]	-0.03 0.06	-0.52** -0.36**	0.61** 0.63**	0.10 0.47**	0.40** 0.41**	0.40** 0.54**
Length of flowering period (days)	-0.04 0.06	1.00 1.00	0.23* 0.29**	0.51** 0.51**	0.03 -0.07	0.17 0.25*	-0.03 -0.01
Length of pod filling period (days)	-0.52** -0.36**	0.23* 0.29**	1.00 1.00	0.15 0.25*	-0.03 -0.20	-0.26* -0.03	-0.39** -0.46**
Length of life cycle (days)	0.61** 0.63**	0.51** 0.51**	0.15 0.25*	1.00 1.00	0.02 0.25*	0.29** 0.43**	0.15 0.26*
Plant height at flowering (cm)	0.10 0.47**	0.03 -0.07	-0.03 -0.20	0.02 0.25*	1.00 1.00	0.77** 0.54**	0.59** 0.65**
Plant height at maturity (cm)	0.40** 0.41**	0.17 0.25*	-0.26* -0.03	0.29** 0.43**	0.77** 0.54**	1.00 1.00	0.80** 0.60**
Bottom seed height (cm)	0.40** 0.54**	-0.04 -0.01	-0.39** -0.46**	0.15 0.26*	0.59** 0.65**	0.80** 0.61**	1.00 1.00

[1/] Upper figures in each pair are from the first planting on July 15

[2/] Lower figures in each pair are from the second planting on August 3

*, **, respectively, significant at 5% and 1% level

life cycle, taller the plants with bottom seed pod at a higher position but shorter the pod filling period (Table 2). High positive correlation coefficients were found between days in the vegetative phase from emergence to flowering and days in life cycle in late-planted soybeans (Weber and Moorthy, 1952 and Akhanda et al., 1976).

The periods (days) for flowering, pod filling and from end of flowering to physiological maturity did not differ greatly due to planting dates but were definitely shorter as the plantings were delayed. However, the differences among cultivars as to these periods were greater ranging from 8 to 23 days (Table 1). The flowering periods were positively related to the pod filling periods ('r' = 0.23* to 0.29**) and length of life cycle ('r' = 0.51**) whereas the pod filling periods were negatively related to bottom pod heights ('r' = -0.39** to -0.46**). The second important phase affecting the life cycle was the period from the end of the flowering to R_7 which differed by 23 days among cultivars in the first planting of 1976. These periods were consistently shorter in second planting in both years probably due to reduced day length and cooler night temperatures. Shorter days reduced the time from flowering to maturity as well as the time from emergence to flowering in soybeans (Hinson and Smith, 1969). The magnitude of the range in pod filling periods and the end of flowering to maturity in both plantings in 1977 were smaller than those of 1976 because the poor performing lines from both extremes (early and late) of earlier trials were not included in the 1977 trial. The length of life cycle varied from 88 to 116 and 83 to 106 days, respectively, in first

and second plantings in 1976; whereas it ranged from 99 to 113 and 84 to 105 days in 1977. The hastening effects of short days on maturity were greater than the delaying effects of cool temperature in second planting. Major et al. (1975b) reported that short day lengths were necessary to offset any delaying effects of cool temperature on the period from flowering to physiological maturity. Johnson et al. (1960) observed that soybean life cycles were shortened by cool temperatures and reduced photoperiods. According to Leffel (1961), a late variety for a given latitude would show less calendar maturity date response to late planting than an early planting. The period from the date of physiological maturity to the date when cultivars were ready for harvest also varied considerably among the lines. Some lines quickly dried within a week and some took more than two weeks. In some cases, the stem remained green though the seeds were shattering. This characteristic should be carefully checked in selecting soybean cultivars and such lines should be discarded.

Effect of planting dates on the average number of calendar days and growing degree days (GDD) or heat units for different periods of physiological growth phases for 84 soybean cultivars or lines in 1977 are presented in Table 3 and in Figures 1 and 2. The calendar days and GDD for different growth phases were computed on the average periods for 84 cultivars. Both calendar days and GDD for various growth phases were higher in the July 15 planting than the August 3 planting. The difference between planting dates

Table 3. Effect of planting dates on the average number of calendar days and growing degree days (GDD) for different periods of physiological growth phases of 84 soybean cultivars or lines planted at Gainesville, FL in 1977.

Periods of physiological growth phases	Calendar days			Growing degree days (GDD)[1/]		
	July 15 planting	August 3 planting	Difference for planting dates	July 3 planting	August 3 planting	Difference for planting dates
Planting to flowering	47	39	8	1548	1255	293
Planting to pod filling (R_5)	65	55	10	2129	1849	280
Planting to end of flowering	80	68	12	2578	2126	452
Planting to physiological maturity	106	92	14	3047	2501	546
Flowering period	34	30	4	1047	861	186
Pod filling period	41	39	2	919	707	212
End of flowering to physiological maturity (R_7)	26	24	2	470	385	85

[1/] GDD = sum of daily mean temperature F minus 50 F (base temperature for soybean)

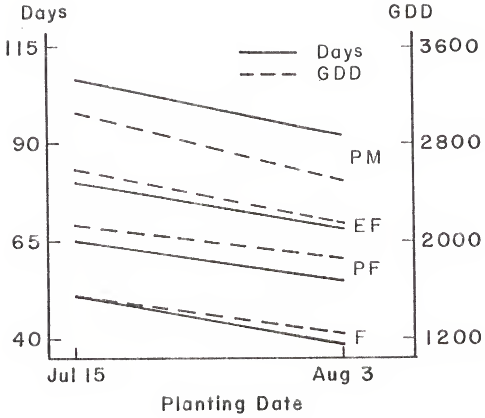

Figure 1. Effect of planting date on the average number of calendar days and growing degree days (GDD) for 84 soybean cultivars or lines from planting to flowering (F), pod filling (PF), end of flowering (EF), and physiological maturity (PM).

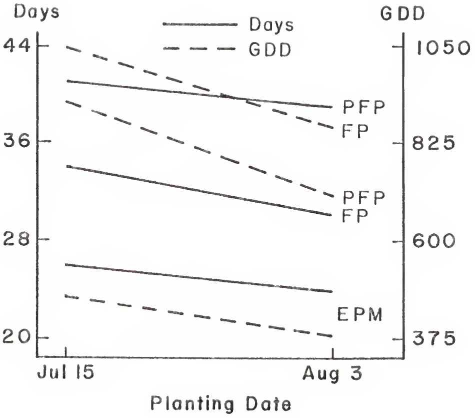

Figure 2. Effect of planting date on the average number of calendar days and growing degree days (GDD) for 84 soybean cultivars or lines for flowering period (FP), pod filling period (PFP), and period from end of flowering to physiological maturity (EPM).

was highest (14 days) in the period from planting to physiological maturity because of accumulative difference in the whole life cycle. The differences in calendar days and GDD were lowest in pod filling period and end of flowering to R_7. As a single factor, the differences in the period from planting to flowering were the highest. To complete the average life cycle, July 15 planting required 3,047 GDD whereas August 3 planting needed 2,501 GDD. Martin and Leonard (1967a) reported that 4,300 GDD or heat units were required to mature soybeans. The difference in GDD between these two findings was probably accounted for by the difference in cultivar, latitude and growing season.

Figures 1 and 2 indicate that calendar days and GDD requirements from planting to flowering, pod filling, end of flowering, R_7, periods for flowering, pod filling and end of flowering to R_7 consistently dropped from July 15 planting to August 3 planting. This phenomenon suggests that planting earlier than July 15 and later than August 3 would require, respectively, greater and smaller GDD beyond the range in the figures. However, the magnitudes of drops in GDD from first to second planting were variable with the greatest drop occurring in planting to flowering period. Major et al. (1975a) reported that the GDD for physiological growth phases were longer for the early planting on May 1 and greatly reduced for the late planting on July 1 in all cases except for the period from planting to beginning of flowering. But in this investigation the sharp drop in GDD for planting to flowering (Figure 1), flowering period and

pod filling period (Figure 2) was particularly influenced by reduced day length and lower temperature as explained earlier. Computation of GDD for the life cycle of soybeans for a particular geographic and climatic region might help in predicting the soybean maturity, which, in turn, will facilitate effective planning for double or multiple cropping with soybean as a legume component particularly in areas having crop seasons limited by low temperature. Growing degree day method is an effective tool used for predicting corn development (Major et al., 1975a).

Data on plant height at flowering and maturity, height of lowest pod and seed yield are given in Appendix Tables 5 and 6. Both the plant height at flowering and maturity and lowest pod heights were drastically reduced in all cultivars in the second planting of both years. Harvest loss with a properly set combine is low if the lowest pod height is more than 15 cm. Even at this height cutterbar loss in the field of more than 2.2% has been reported by Park and Webb (1959). Weber and Fehr (1966) found a 1.9% loss in yield for each 2.5 cm increase in height of cut from ground level up to 16 cm height. In the first planting of 1976 and 1977, respectively, 42 out of 129 and 50 out of 84 cultivars had minimum pod heights of 15 cm. In the second planting, 12 of 129 produced pods at 15 cm or above but none in 1977 though there were 12 lines having lowest pods at 12 cm or above. Generally, plant height at flowering and maturity and height of lowest pods were increased as the length of vegetative growth periods were longer. Hinson (1974) observed that late flowering increased the height of the lowest pods. Bottom

pod height had positive correlations with planting to flowering days ('r' = 0.40** to 0.54**), plant height at flowering ('r' = 0.59** to 0.65**) and maturity ('r' = 0.80** to 0.61**). It had strong negative correlation with length of pod filling period ('r' = -0.39** to -0.46**) demonstrating that the longer the pod filling period the closer the first pod to the ground to be filled. Plant height responded positively to increased days to maturity (Table 2). Whigham (1975) stated that a longer season permitted taller growth of the plants and taller plants better utilized available light by developing greater photosynthetic leaf area.

Seed yields among cultivars ranged, respectively, from 2,260 to 4,550 and 2,060 to 3,660 kg/ha in the first planting of 1976 and 1977 (Appendix Tables 5 and 6). The ranges in the second plantings were, respectively, from 820 to 3,130 and 1,080 to 2,410 kg/ha. The seed yields of ten promising lines out of 129 in 1976 and 84 in 1977 are shown in Table 4. Only F73-9564 produced the highest yield in the first planting of both years. The highest seed yields for the second planting were, from F74-2155 and F74-3514, respectively, in 1976 and 1977. They produced very high in one year and very low in the other. However, the average of both years was highest (2,380 kg/ha) from F74-3510 which did not differ much from Santa Rosa. The ten most promising lines were altogether different in the first and second plantings except F72-5823 which consistently gave higher seed yields in both plantings both years. Among the varieties used as control, Jupiter selection produced most and Santa Rosa least in the first planting whereas the latter produced the most

Table 4. Seed yields and bottom pod heights of 10 promising cultivars or lines of soybeans selected from 1976 and 1977 trials at Gainesville, FL.

Promising cultivars or lines	Average bottom pod height[1/]	Seed yield of first planting			Promising cultivars or lines	Average bottom pod height[1/]	Seed yield of second planting		
		1976	1977	Average			1976	1977	Average
	(cm)	--------kg/ha---------				(cm)	--------kg/ha----------		
F73-9564	12	4550	3660	4110	F74-3510	5	2550	2200	2380
F71-1606	21	4040	3390	3720	F74-9458	9	2370	2310	2340
F72-5823[2/]	20	3870	3530	3700	F74-2122	11	2750	1900	2330
F74-2128	18	3850	3540	3700	F74-2155	13	2760	1860	2310
F73-9341	9	3670	3570	3620	F75-7941	5	2600	1880	2240
F74-2080	13	3550	3570	3560	F74-1976	13	2200	2180	2190
F74-3489	9	3610	3620	3550	F75-7201	9	2730	1630	1280
F75-7147	15	3970	3100	3540	F72-5823[2/]	9	2100	2140	2120
F74-2684	14	3810	3130	3470	F73-9415	7	1900	2260	2080
F74-3493	12	3600	3100	3350	F74-3514	8	1570	2410	1990
Control					Control				
Jupiter Sel.	24	3170	3110	3140	Santa Rosa	17	3130	1520	2330
Vicoja	16	2910	3100	3010	Cobb	8	2320	2200	2260
Cobb	7	3310	2240	2880	Miniera	6	2030	1660	1850
Miniera	14	3360	2380	2870	Vicoja	6	2030	1410	1720
UFV-1	21	3010	2600	2810	UFV-1	12	1750	1620	1690
Santa Rosa	18	3110	2400	2760	Jupiter Sel.	9	960	1490	1230

1/ Average of 1976 and 1977

2/ Only cultivar did well in both plantings and both years

and the former the least in the second planting. Among the cultivars and lines used in this study, neither the earliest nor the latest maturing types were superior in seed yields.

Correlation analysis on 1977 data revealed that seed yields were positively correlated with length of flowering period ('r' = 0.35**), length of pod filling period ('r' = 0.35**) and length of life cycle ('r' = 0.37**) and for the increase of each day in these periods, respectively, the seed yields increased by 61, 59 and 39 kg/ha in first planting (Table 5). Seed yields were also directly related to plant heights both at flowering and at maturity with 'r' values of 0.27* and 0.25*, respectively. Similar relationships were also detected in all cases in the second planting except plant height at flowering. Periods from planting to flowering which were mostly responsible for the length of life cycle were not related to seed yields. Again one of the known strategies for increasing soybean productivity is to increase the length of pod filling period (Orgen, 1978) which is directly related to flowering period. If part of the planting to flowering period could be transferred by breeding to extend flowering and pod filling periods, then the growth patterns of soybean could be engineered to provide a more efficient seed-producing plant. However, the various relationships discussed in this paragraph and earlier provide potential clues for breeders in determining their course of action in improving and developing soybean genotypes. Weber and Moorthy (1952) suggested that selection for high oil may be effective by choosing plants of early flowering and a lengthened period from flowering to maturity.

Table 5. Correlations coefficients between yields and different characteristics and predicted equations on yields for 84 soybean cultivars or lines at two planting dates at Gainesville, FL in 1977.

Characteristics	Yield (July 15 planting) Correlation coefficient ('r' values)	Yield (July 15 planting) Regression equation (predicted linear model)	Yield (August 3 planting) Correlation coefficient ('r' values)	Yield (August 3 planting) Regression equation (predicted linear model)
Days from planting to flowering	N.S.		N.S.	
Length of flowering period	0.35**	$\hat{Y} = 872 + 61X$ (X=day)	0.44*	$\hat{Y} = 232 + 53X$ (X=day)
Length of pod filling period	0.35**	$\hat{Y} = 516 + 59X$ (X=day)	0.49**	$\hat{Y} = -486 + 62X$ (X=day)
Plant height at flowering	0.27*	$\hat{Y} = 1836 + 17X$ (X=cm)	N.S.	
Plant height at maturity	0.25*	$\hat{Y} = 2715 + 13X$ (X=cm)	0.27*	$\hat{Y} = 1357 + 11X$ (X=cm)
Lowest pod height	N.S.		N.S.	
Length of life cycle	0.37**	$\hat{Y} = 1172 + 39X$ (X=day)	0.34	$\hat{Y} = -441 + 24X$ (X=day)

N.S. = relationship is not significant
*significant at 5% level
**significant at 1% level

The growth and development of the soybeans during 1976 and 1977 late-planting seasons were good. Plants obtained near maximal size for the planting dates on mineral soils. July and August planted soybeans risk early frost and freeze damage. Radiation frosts have occurred in late October in north and west Florida. At similar latitudes the chances of a freeze increases throughout the month of November. Most of the soybeans in the first planting matured on or before November 1 in 1977 but many did not mature until November 10 in the second planting where Jupiter selection reached physiological maturity on November 16. There was no early frost in 1977, but in 1976 a frost on November 6 damaged, respectively 7 and 19 cultivars in the first and second plantings. A freeze 10 days earlier would have severely damaged many entries in the second planting.

The results of this study indicate that there are potential lines in the test materials which could be developed as cultivars for use as a second crop in warm season double cropping systems. In addition to the increased production per unit area, soybean as a late planted crop offers other advantages. Increased protein content (Cartter and Hartwig, 1962) and improved seed quality (Abel, 1961 and Osler and Cartter,1954) are associated with late planting due to seed development under the influence of lower temperature. Moreover, soybean has an ability to yield well when planted over an extended time period which permits soybeans to complement other crops in an area by allowing more efficient use of the operator's labor and machinery (Pendleton and Hartwig, 1976).

It was found that corn in a corn-soybean rotation yielded about seven bushels more than continuous corn (Mulvaney et al., 1973 and Barber, 1978). But late-planted soybean as a second crop in double or triple cropping systems must be planted in narrow row spacings (Yeager et al., 1967; Thurlow, 1971b and Harris and Stacy, 1961).

The yield data of this study suggest that all 10 selected lines in Table 4 from first planting and especially F73-9564, F71-1606 and F73-5823 have potentials for July planting in double cropping systems in the tropical and subtropical regions. They offer promise for yields higher than from the varieties presently available for normal planting. Similarly, F74-3510, F74-9458 and F74-2122 can be used for later planting in early August. F72-5823 might do equally well in both late-July and early-August plantings. However, further studies on the promising lines are necessary prior to recommending one or more of them for commercial use.

Experiment 2. Effect of plant population and row width on the yield and yield components of sorghum

Plant height, LAI, panicle length and grain yield as influenced by cultivars, row widths and plant populations are shown in Table 6. With the increasing plant population, LAI and panicle length, increased and decreased, respectively, rather consistently. Plant height increased with populations from 20 to 30 plants/m^2 and remained the same with further increases in population; whereas the grain yield significantly increased with populations from 20 to 30 plants/m^2 and then decreased sharply (Figure 3).

Table 6. Effect of cultivars, row width and plant population on the seed yield and other agronomic characteristics of sorghum planted at Gainesville, FL in 1977.

Treatments	Days from planting to flowering	LAI after flowering	Plant height at maturity	Panicle length	Seed yield[1/]
			(cm)	(cm)	(kg/ha)
1. Effect of cultivar:[2/]					
TE Bird-A-Boo II	72	4.30	92	23	3640 a
Pioneer B-815	76	4.64	114	22	3930 a
2. Effect of row width:					
41 cm	74	5.00	104	24	4020 a
61 cm	74	4.12	105	23	3580 a
91 cm	73	4.30	101	22	3760 a
3. Effect of population:					
20 plants/m^2	74	3.55	101	24	3550 b
30 plants/m^2	74	4.51	105	23	4130 a
40 plants/m^2	74	5.36	105	22	3680 ab

1/Seed yields not followed by same letter are significantly different at 5% level according to Duncan New Multiple Range Test at 5% level

2/Planted March 22, 1977; Harvested Bird-A-Boo II on June 30 and Pioneer B-815 on July 7, 1977

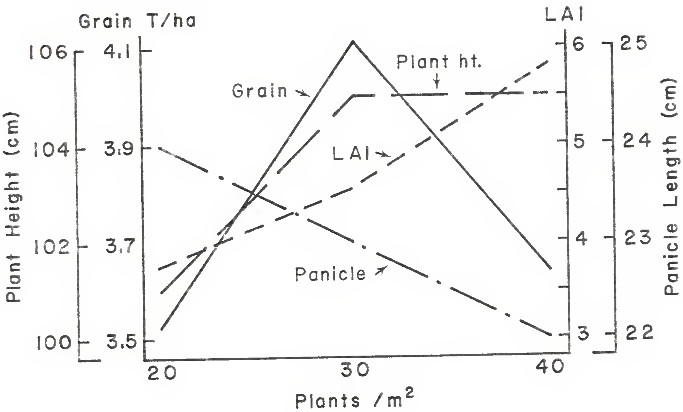

Figure 3. Effect of plant population on plant height, leaf area index (LAI), panicle length and grain yield of sorghum.

TE Bird-A-Boo II reached physiological maturity one week earlier than Pioneer B-815. The period from planting to flowering was 72 days for TE Bird-A-Boo II and 76 days for Pioneer B-815 and the GDD required for this growth phase were, respectively, 890 and 979. For completing the life cycle (planting to black layer development) the former required 1,543 heat units (GDD) whereas the latter needed 1,700 heat units. Raghunatha (1977) reported that there was a delay in heading by 1.3 days by increasing population. But neither the row width nor the plant population influenced the period from planting to flowering in this experiment. Plant height at maturity was 114 cm for Pioneer B-815 and 92 for TE Bird-A-Boo II. The plant height was highest (105 cm) with 61 cm row width and lowest (101 cm) in rows 91 cm apart and it increased from 101 at 20 plants/m^2 to 105 cm at 30 and 40 plants/m^2. Stickler and Yunis (1966) obtained a significant interaction for height X variety and height X stand density but little evidence for row-width X plant height interaction. They concluded that under strong competitions, the short type may better withstand the effects of strong competition resulting from higher plant densities. Balanarasaiah et al. (1972) reported that the higher stover yield in higher population was associated with significantly taller plants than in lower population and the stem was significantly thinner with higher population than with the lower.

Pioneer B-815 produced higher LAI (4.64) than TE Bird-A-Boo II (4.30). Narrow row width (41 cm) resulted in the highest LAI (5.00) as compared to the wider row widths of 61 and 91 cm where the LAI were, respectively, 4.12 and 4.30. This was probably due to higher

competition in the wider row width as higher number of plants were close together as compared to lower row spacing where plants were distributed over wider area. Umrani and Bhoi (1977) found in a standard plant density of 100,000 plants/ha planted at 45 and 90 cm rows that total root growth was 18% higher in wider spacing because of the higher competition for nutrients among the plants close together as compared to that of narrower spacing. LAI increased consistently from 3.55 at 20 plants/m^2 to 5.36 at 40 plants/m^2. The rate of increase in LAI was 0.15 for increase of each plant/m^2 ($\hat{Y} = 0.58 + 0.15X$) and the relationship was highly significant with a 'r' value of 0.95** (Figure 4A). Maunder (1972) indicated that in wide row spacings (102 cm) and under fairly low populations, sorghum will produce a LAI of 3.00 or below. Panicle length had a tendency to decrease with the increasing row width and plant population due to increased plant competition. Higher soil fertility and lower plant population were found to promote a longer panicle through the increase in rachis internode length and number of internodes, respectively (Blum, 1967).

The grain yields were 3,930 and 3,640 kg/ha, respectively, from Pioneer B-815 and Bird-A-Boo II. These yields were very low when compared to those obtained by Green (1973, 1977a) and were probably due to low temperature at early stages of growth because of early planting (March 22) and weed competition. Due to stunted growth induced by low temperatue, the sorghum plants could not quickly cover the soil surface and the weed growth was profuse in many plots.

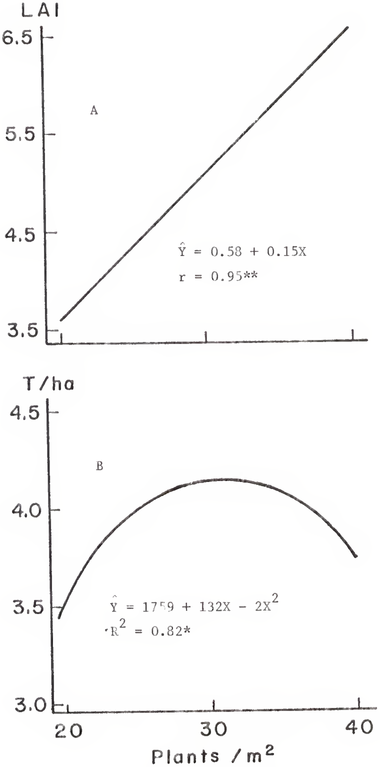

Figure 4. Relationship of plant population with LAI (A) and grain yield (B) in sorghum.

The weed control was not complete under the high level of mechanization. Changes in row width did not significantly affect the grain yield. However, the highest amount of grain (4,020 kg/ha) was obtained from the narrowest row width (41 cm) followed by 3,760 and 3,580 kg/ha, respectively, for 91 and 61 cm rows. A progressive reduction in grain yields in a linear pattern occurred as row widths narrowed from 120 cm to 25 cm (Robinson et al., 1964; Chamy and Balasubramaniam, 1970). Karchi and Rudich (1966) and Stickler and Wearden (1965) concluded that yield superiority of sorghum hybrids in narrow rows with wide intrarow seedling spacings was due primarily to increased number of heads per unit area. As a contrast, Chandravanshi (1976) in India did not find any significant difference in yields in a range of row spacings from 45 to 125 cm.

The grain yield (4,130 kg/ha) was significantly highest from 30 plants/m^2 followed by 3,680 kg/ha for 40 plants/m^2 with the lowest (3,550 kg/ha) for 20 plants/m^2. Fischer and Wilson (1975) and Mane et al. (1977) also claimed that grain yields were significantly increased with the increase in plant density, respectively, from 14,350 to 645,830 and 45,000 to 180,000 plants/ha. Fischer and Wilson obtained the highest yield of 15.5 g m^{-2} day^{-1} of crop life of 91 days from 645,830 plants/ha whereas in this experiment the highest yield/m^2/day was 4.13 g from 300,000 plants/ha. As against these findings, Reddy and Murty (1977) did not detect any differences in yields in a number of population treatments from

45,000 to 180,000 plants/ha and Rao et al. (1976a) got lowest yield at the highest population due to decrease in panicle and 100 seed weight and increased lodging.

Regression analysis revealed that the grain yield was curvilinearly related to plant population and the associated LAI ($\hat{Y} = 1759 + 132X - 2X^2$) with a significant R^2 value of 0.82* (Figure 4B). The grain yield was increased by 132 kg/ha for the increase of each plant/m^2 from 20 plants/m^2 with a LAI of 3.55 to 30 plants/m^2 having a LAI of 4.51 and then decreased by 2 kg/ha for further increase of each plant/m^2 to 40 plants/m^2 with a LAI of 5.36. A similar curvilinear relationship between grain yield and leaf area was found by Stickler and Pauli (1961). It was observed that lack of uniformity in heading and maturity among tillers in a plot increased with the increasing plant population creating a harvest problem and increasing harvest loss. Ross (1977) stated that 100,000 and 150,000 plants/acre would be too thick and plants would have small heads, lack of uniformity and probably run into harvesting problems. He indicated that lower population, rather than have plants crowded together, will give all around better results as the sorghum plant has an amazing capacity to sucker. But the grain yield of the late-maturing hybrid was highest under the low plant density and that of an early-maturing hybrid was highest under the high plant density (Blum, 1970). However, the remarkable constancy of sorghum yield from widely different stand densities, as appeared in the above discussion, probably resulted from intercompensation

among yield components, particularly heads/unit area and seeds/head. Similar views were expressed by Stickler and Wearden (1965).

For developing profitable intercropping systems, Reddi and Reddy (1976a) and Bapat et al. (1976), respectively, suggested 60 and 90 cm row widths for sorghum in India. Murty and Reddy (1977) indicated that row width of sorghum can be extended to 60 cm for developing suitable intercropping systems without sacrificing the grain yield of the base crop, sorghum. An additional benefit of raising suitable intercrops between row crops of sorghum could be a higher monetary return to the farmers growing a rainfed sorghum crop in the humid tropics.

From the above discussion, sorghum seems to have a great elasticity to adjust itself in a wide range of row widths and plant densities and produce high yield under varied conditions. Due to its potential elasticity, it could be an excellent component of multiple cropping systems in the tropics. Intercrops of sorghum in areas having distinct six-month wet and dry cycles will make better use of residual moisture and nutrients in the soil.

Experiment 3. Effect of plant population and row width on the yield and yield components of sunflowers

Effects of cultivars, row widths and plant populations on plant height, number of leaves per plant, LAI, diameter of stem above 12th leaf, diameter of head, 100-seed weight and seed yield are shown in Table 7.

Table 7. Effect of cultivars, row width and plant population on the seed yield and yield components of sunflowers, Gainesville, FL in 1977.

Treatments	Plant ht. at maturity	Number of leaves/plant after flowering	LAI after flowering	Diameter of stem above 12th leaf	Diameter of head	100 seed weight	Seed yield
	cm			cm	cm	g	kg/ha
1. Effect of cultivars:							
Interstate 891	175	26	5.72	2.28	18	5.12	2670 a*
Sun-Hi 304	171	28	5.06	2.34	18	4.41	2380 a
Cargill 204	169	29	5.49	2.21	18	4.49	2460 a
2. Effect of row width:							
41 cm	168	28	5.13	2.29	18	4.56	2530 a
61 cm	169	28	5.33	2.21	18	4.62	2560 a
91 cm	178	28	5.80	2.34	18	4.84	2420 a
3. Effect of population:							
4 plants/m^2	163	28	3.35	2.62	21	5.14	2240 c
6 plants/m^2	172	28	5.43	2.26	18	4.54	2510 b
8 plants/m^2	181	27	7.49	1.96	15	4.34	2750 a

*Seed yields not followed by the same letter are significantly different at 5% level.

The plant height, LAI and seed yield consistently increased (Figure 5) with the increase in plant population. Interstate 891 produced the tallest plant (175 cm) followed by Sun-Hi 304 (171 cm) and Cargill 204 (169 cm). Plant height had a tendency to be higher with increased row widths. With increasing plant populations the plant height increased consistently from 163 cm at 4 plants/m^2 to 181 cm at 8 plants/m^2. This relationship was highly significant ($r = 0.75^{**}$). Plant height increased by 4.69 cm for increase of each plant/m^2 (Table 8). Robinson et al. (1976) also reported that plant height increased with increased plant density. But Karami (1977) found that plant height decreased slightly with increasing plant population. Diameter of stem decreased significantly ($r = -0.84^{**}$) by 0.18 cm for the increase of each plant/m^2 (Table 8). Plants at highest population were observed to be more susceptible to lodging due to thinner stems when compared to lowest population. Diameter of stem did not differ much due to either cultivar or row width.

LAI increased dramatically with the increases in plant population and the effect of cultivar and row width was very small. LAI increased from 3.35 at 4 plants/m^2 to 7.49 at 8 plants/m^2. Correlation analysis revealed that LAI was increased by 1.04 for the increase of each plant/m^2 (Figure 6) and the relationship was highly significant ($r = 0.94^{**}$). Similar results were obtained by Vicherkova and Souckova (1976) and Srinivas and Palit (1977) who also stated that dry matter production increases with increasing LAI.

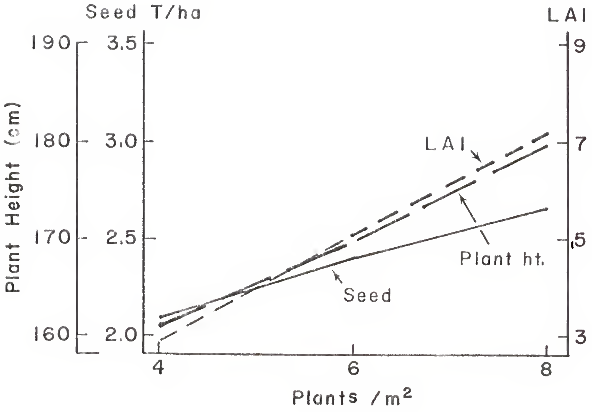

Figure 5. Effect of plant population on plant height, leaf area index (LAI) and seed yield of sunflowers.

Table 8. Correlation coefficients and predicted regression equations between various measurements in sunflowers grown at Gainesville, FL in 1977.

Factors Related (Dependent vs Independent)	Predicted Regression Equation	Correlation coefficient 'r' values
Plant height (cm) vs population	$\hat{Y} = 144.75 + 4.69X$ (X=plants/m^2)	+0.75**
Diameter of stem (cm) vs population	$\hat{Y} = 3.34 - 0.18X$ (X=plants/m^2)	-0.84**
Seed yield (kg/ha) vs LAI	$\hat{Y} = 1840 + 122X$ (X=LAI)	+0.85**
Seed yield (kg/ha) vs diameter of stem (cm)	$\hat{Y} = 4260 - 722X$ (X=cm)	-0.87**
Seed yield (kg/ha) vs diameter of head (cm)	$\hat{Y} = 4032 - 85X$ (X=cm)	-0.84**

**Significant at the 1% level.

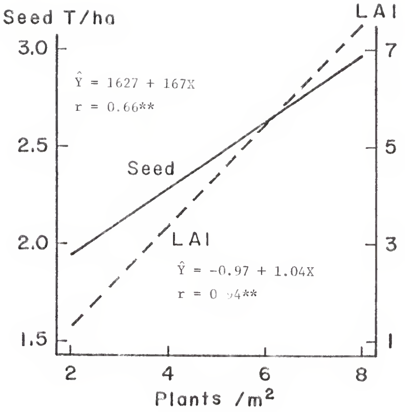

Figure 6. Correlation of plant population with seed yield and LAI in sunflowers.

Wassink and Van Den Noort (1976) found a LAI of 13.2 from a solitary sunflower plant and indicated that LAI's will range from three to four in close planting under field conditions.

Both diameter of head and stem and 100-seed weight decreased sharply with the increasing plant population (Figure 7). This result substantiates the finding of Karami (1977) that closer plant spacing resulting in higher plant density reduced the diameter of head and 1000-seed weight in 'Record' cultivar of sunflower in Iran. For each increase of one plant/m^2, the diameter of head and 100-seed weight were decreased by 1.42 cm and 0.20 gm, respectively, with 'r' values of -0.96** and -0.64** (Figure 8) which were significant at 1% level. These phenomena demonstrate the increased intraspecific competition of the plant for nutrients, water, CO_2 and solar radiation with increasing population which resulted in the smaller heads and lighter seeds.

Even with an adequate supply of nutrients and water, radiant energy may become a limiting factor at high plant population. With increasing plant population, leaf surface area will increase but the potential leaf area for photosynthesis may not increase beyond a particular point due to mutual shading of leaves. Working on sunflower, Varghese et al. (1976) found a significant decline in leaf efficiency for photosynthesis at LAI beyond 2.78 with a resultant decrease in net assimilation rate (NAR) per unit of photosynthesizing tissue. However, the mutual shading effect will be

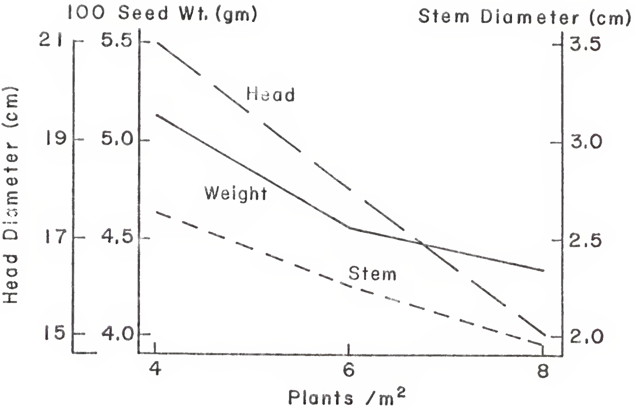

Figure 7. Effect of plant population on the diameter of stem and head and 100 seed weight of sunflowers.

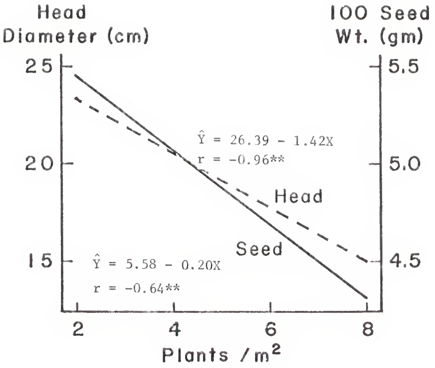

Figure 8. Correlation of plant population with diameter of head and 100 seed weight in sunflower.

minimum in varieties which can change their orientation in relation to incoming light because of much higher mobility of leaf blade or petiole as compared to those in which leaf orientation remains relatively constant (Klimov et al., 1977). Different cultivars and row widths had a very small effect on 100-seed weight and no effect at all on diameter of head. High population plants have the advantage of small heads that remain upright and dry faster than large heads. The large heads at low populations will dry slowly and may create a harvest problem particularly at high humidity (Robinson et al., 1976).

The calendar days and GDD required by each cultivar from planting to flowering and planting to physiological maturity (life cycle) are presented in Table 9. The GDDs from planting to flowering were 2,885, 2,789 and 2,837, respectively, for Interstate 891, Sun-Hi 304 and Cargill 204 under Gainesville conditions. These heat units were very high as compared to 1,331 ± 76 for 'Sunfola 68' variety of sunflower obtained by Keefer et al. (1976) in Australia. Magoon and Culpepper as cited by Wilsie (1962) found that corn grown in Maine and New York required a far smaller heat unit summation than the same corn grown in Virginia, indicating the important influence of day length, insolation and possibly the respiration of the plant.

Interstate 891, Sun-Hi 304 and Cargill 204 required 4,340, 4,039 and 4,241 GDD, respectively, to complete their life cycles. Determination of GDD required at a particular location is extremely important in forecasting maturity date of sunflower and including

Table 9. Calendar days and growing degree days (GDD) from planting to flowering and planting to maturity (life cycle) for three sunflower cultivars, Gainesville, FL in 1977.

Cultivar	Days from planting to flowering		Length of life cycle	
	Calendar days	GDD	Calendar days	GDD
Interstate 891	79	2885	111	4340
Sun-Hi 304	77	2789	105	4039
Cargill 204	78	2837	109	4241

it in a double cropping system especially in areas where the cropping season is limited by low temperature.

Seed yield of 2,750 kg/ha from the highest population of 8 plants/m^2 was the significantly highest followed by 2,510 kg/ha from 6 plants/m^2 and 2,240 kg/ha from 4 plants/m^2. Similar results were obtained by Zubriski and Zimmerman (1974) and Massey (1971). In India, seed yield increased as population increased from 2.0 to 6.7 plants/m^2 and then decreased as population increased up to 20.1 plants/m^2 (Vijayalakshmi et al., 1975). Yield differences were found also by Johnson and Marchant (1973) among populations between 2.5 and 7.2 plants/m^2 in Georgia. Under sprinkler irrigation in California, yields increased slightly as population decreased from 48.0 to 5.5 plants/m^2 (Lehman et al., 1973). Whereas Alessi et al. (1977) obtained highest yield for the lowest population from a range of 2.5 to 10 plants/m^2. From the above results, it is very difficult to come to a decisive conclusion as to the effect of plant population on seed yield. However, the highest seed yield from the highest population can be attributed to increased LAI and number of heads per unit area.

A direct correlation was established between the magnitude of the yield and leaf surface area by Rubin et al. (1975). Likewise, seed yields were increased by 167 and 122 kg/ha, respectively, due to each increase of one plant/m^2 and each unit of LAI (Figure 6 and Table 8) in this experiment. The relationships were highly significant at 1% level with 'r' values of 0.66** and 0.85**.

Tsvetkova (1977) reported that 'Peredovik' sunflower produced highest seed yields of high quality with a leaf area of 25,000 m^2/ha (LAI = 2.50). Similar results were obtained by Srinivas and Palit (1977), who also found that the higher the LAI, the higher the seed yield.

As the diameter of stem and head increased with decreasing plant populations, the seed yields dropped sharply. For each unit increase in diameter of stem and head the seed yields were decreased by 772 and 85 kg/ha, respectively, indicating the significant relationships ('r' values, -0.87** and -0.84**) between them (Table 8). However, the negative effect of increasing plant population on diameter of stem, head and 100-seed weight was balanced and superceded by the number of heads per unit area in producing higher seed yield at higher plant population.

Interstate 891 produced the most seed yield (2,670 kg/ha) followed by Cargill 204 (2,460 kg/ha) and Sun-Hi 304 (2,380 kg/ha) with no significant difference among them. In a similar trial earlier, Interstate 891 produced the highest yield as compared to others (Green, 1977b). Neither the row widths nor the interaction between row width and plant population had any significant effect on seed yield. In tall cultivars, seed yield was not affected by spacing between or within rows (Pacucci and Martignano, 1975) but significant interactions between populations and row widths on seed yield occurred in two trials out of eleven in Minnesota (Robinson et al., 1976).

Data on oil yield and fatty acid composition are presented in Table 10. Oil yield was highest (1,200 kg/ha) for Interstate 891 followed by Sun-Hi 304 (1,100 kg/ha) with the lowest for Cargill (1,090 kg/ha). Total oil on dry basis was maximum (46.4%) from Sun-Hi 304 and minimum (44.3%) in Cargill 204. All the cultivars produced about 91% unsaturated fatty acids mainly oleic (18:1) and lenoleic (18:2) acids which are very important components as far as the quality of edible oil is concerned. The ratio (12:1) of unsaturated to saturated fatty acids was quite high making it highly desirable as an edible oil in the light of evidence in linking saturated fats to high blood cholesterol and associated incidence of heart disease (Vergoessen, 1970). The percentage of lenoleic acid content ranged from 49.0 to 54.0. This indicates that such oil would be ideal as an edible oil from the stability and flavor aspect as indicated by Robertson (1975). However, the degree of unsaturation of sunflower oil has been found to be largely dependent on the climatic conditions during the growing season (Kinman and Earle, 1964). Increasing the plant density from 1.0 to 4.0 plants/m^2 increased oil content and protein content (Stoyanova et al., 1975). Similarly, Robinson et al. (1976) reported that oil percentage decreased as population increased. But there are also available example showing that the average seed oil content was highest at 48.98% for the lowest population of 1.67 plants/m^2 in a range of population treatments up to 8.0 plants/m^2 (Leocov, 1977). However, the data presented

Table 10. Oil yield and fatty acid composition of three sunflower cultivars, Gainesville, FL in 1977.

Cultivar	Seed yield	Total oil (dry basis)	Oil yield	Fatty acid composition			
				Palmitic 16:0 1/	Stearic 18:0 1/	Oleic 18:1 2/	Lenoleic 18:2 2/
	kg/ha	%	kg/ha	%			
Interstate 891	2670	45.8	1200	4.8	2.7	42.8	49.0
Sun-Hi 304	2380	46.4	1100	5.0	2.2	40.1	51.7
Cargill 204	2760	44.3	1090	5.6	2.4	37.1	54.0

1/ Saturated fatty acid

2/ Unsaturated fatty acid

and discussion above suggest that Interstate 891 with the highest population of 8.0 plants/m^2 would be the best choice under tropical conditions and may be planted with any spacing between rows that is convenient up to 91 cm.

Experiment 4. Intercropping Peanut, Pigeonpea and Sweet Potato in Corn

Corn

Analysis of variance did not detect any interaction between corn hybrids and intercrops on the grain yield of corn. This indicates that the intercrops did not compete with corn during their early stages of growth and thus did not affect corn yields. When legumes were grown in corn, Banta and Harwood (1975) also found very little reduction in corn yield.

The mean grain yield, ears/plant, plant height, LAI and the length of life cycle of three corn hybrids as influenced by plant populations are shown in Table 11. The effect of plant population on the average plant height, LAI, ears per plant and grain yield of three corn hybrids are presented in Figure 9. The highest grain yield was obtained from McNair 508 (7,240 kg/ha) at 4.8 plants/m^2 followed by Pioneer 3369A (7,150 kg/ha) at 4.8 plants/m^2 and Pioneer 3780 (6,970 kg/ha) at 7.2 plants/m^2. The grain yields from Pioneer 3780 and Pioneer 3369A at 4.8 and 7.2 plants/m^2 were significantly higher than those at 2.4 plants/m^2. Productivity of the above two hybrids at 4.8 and 7.2 plants/m^2 did not differ statistically. McNair 508 produced significantly higher yield at 4.8 plants/m^2

Table 11. The plant height at maturity, leaf area index, number of ears per plant and grain yield for three corn hybrids grown at three plant populations, Gainesville, FL in 1977.

Hybrid (maturity)	Corn population (plants/m^2)	Plant height (cm)	LAI	Ears/ plant (No.)	Grain yield (kg/ha)	Life cycle: Calendar days	Life cycle: GDD
Pioneer 3780 (early)	2.4	243	1.50	1.52	4740 b*	109	2515
	4.8	255	2.89	1.02	6830 a		
	7.2	254	4.34	0.96	6970 a		
	Average	251	2.91	1.17	6180 A		
Pioneer 3369A (medium)	2.4	267	1.75	1.19	4770 j	121	2857
	4.8	279	3.34	1.01	7150 i		
	7.2	274	4.52	1.00	6490 i		
	Average	273	3.20	1.07	6140 A		
McNair 508 (late)	2.4	289	2.79	1.22	5890 m	133	3206
	4.8	306	5.24	1.18	7240 l		
	7.2	296	7.42	0.91	5510 m		
	Average	297	5.15	1.10	6210 A		

*Corn yield not followed by the same letter are significantly different at 5% level

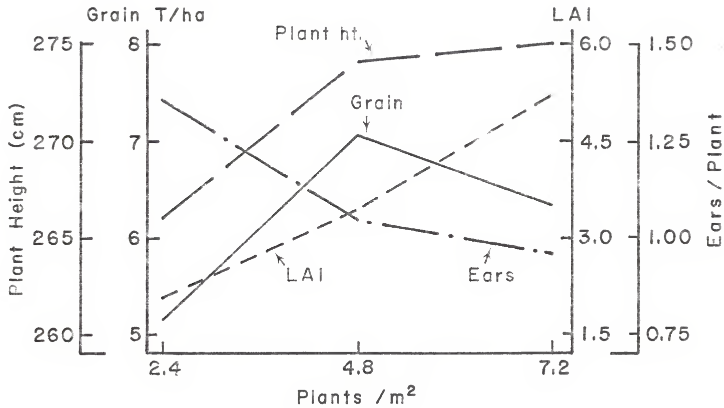

Figure 9. Effect of plant population on the plant height, leaf area index (LAI), ears per plant and grain yield of corn.

as compared to 2.4 and 7.2 plants/m^2, but its yields were not significantly different at the lowest and the highest plant populations. The Duncan Multiple Range Test (Table 12) on corn grain yields of different treatment combinations indicated that Pioneer 3369A at 4.8 plants/m^2 with Florunner peanut at 46 cm row spacing as intercrop produced the highest amount of grain (7,820 kg/ha). But this yield was not significantly different from 17 other treatment combinations out of the 24. Further, no pure stand hybrid corn plot at 4.8 plants/m^2 produced significantly higher grain yield when compared to those with intercrops. This clearly demonstrates that the intercrops had little, if any, effect on the yield of corn. Intercrop row spacings of 46 and 91 cm did not make any difference in corn yield, but all corn hybrids at the lowest population (2.4 plants/m^2) produced significantly lower yields than the others.

In general, the corn yields were lower than those of the previous year obtained from the same hybrids (Akhanda et al., 1978). The lower yield was probably due to extremely dry weather during the growing season of 1977 at Gainesville as compared to 1976 (Appendix Table 7). However, the regression analysis revealed a curvilinear relationship ($\hat{Y} = 582 + 2446X - 299X^2$; $R^2 = 0.64$**) between plant populations and grain yields (Figure 10). This indicates that the increase in plant population from 2.4 to 4.8 plants/m^2 increased the grain yields by 2,446 kg/ha for each increase of one plant/m^2 and then decreased by 229 kg/ha for each further increase of one plant/m^2 beyond 4.8 plants/m^2.

Table 12. Yield of the main corn crop and different intercrops in corn at Gainesville, FL in 1977.

Corn hybrid (maturity)	Corn population (plants/m^2)	Intercrops: Crop	Intercrops: Row spacing (cm)	Corn yield[1] (kg/ha)	Intercrops yield (kg/ha)	Combined yield (kg/ha)
Pioneer 3780 (early)	2.4	Florunner peanut	91	4740 e	160	4900
	4.8	None		6490 a-d		6490
		Florunner peanut	91	7290 abc	370	7660
		Dixie Runner peanut	91	6490 a-d	320	6810
		Early Bunch peanut	91	7030 abc	330	7360
		Alabama Nugget sweet potato	91	7270 abc	1120[2]	8390
		Red Jewel sweet potato	91	6380 bcd	1740[2]	8120
	7.2	Florunner peanut	91	6970 abc	400	7370
Pioneer 3369A (medium)	2.4	Florunner peanut	91	4770 e	420	5190
	4.8	None		7060 abc		7060
		Florunner peanut	91	7060 abc	330	7390
		Florunner peanut	46	7820 a	210	8030
		Dixie Runner peanut	91	6390 abc	280	6670
		Dixie Runner peanut	46	7590 ab	310	7900
		Early Bunch peanut	91	7430 ab	200	7630
		Early Bunch peanut	46	6330 a-d	600	7330
		Alabama Nugget sweet potato	91	7600 ab	2230[2]	9830
		Red Jewel sweet potato	91	6190 bcd	1230[2]	7420
		Norman pigeonpea	91	7050 abc	8560[3]	15610
	7.2	Florunner peanut	91	6490 a-d	630	7120
McNair 508 (late)	2.4	Florunner peanut	91	5890 cde	380	6270
	4.8	None		7550 ab		7550
		Florunner peanut	91	6920 abc	470	7390
	7.2	Florunner peanut	91	5510 de	440	5950

[1] Corn yield not followed by the same letter are significantly different at 5% level.

[2] Root yield of sweet potato.

[3] Forage yield (dry matter).

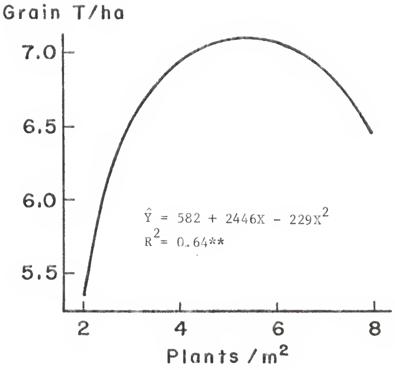

Figure 10. Correlation between plant population and grain yield in corn.

Variation in plant population had a marked effect on LAI and ears/plant but little effect on plant height (Figure 9). However, the plant height tended to be higher with increasing population. The LAI consistently increased with increasing plant population. It ranged from 1.05 to 7.42 and the late maturing hybrid produced higher LAI as compared to early and medium. With the increase of each plant/m^2 LAI was increased by 0.71 ($\hat{Y} = 0.66 + 0.71X$; $r = 0.72^{**}$) and the relationship was highly significant (Table 13). Earley (1965) reported that LAI increased from 0.7 to 2.9 when the plant population was increased from 9,880 to 93,900 plants/ha. Unlike LAI, ears per plant sharply decreased with increasing plant population indicating that 'the higher the LAI the lower the ears per plant' relationship. Ears per plant decreased by 0.07 with the increase of each plant/m^2 ($\hat{Y} = 1.14 - 0.07X$; $r = -0.71^{**}$) as shown in Table 13. Similar relationships in corn were reported by Duncan (1958) and later confirmed by Brown et al. (1970). The percentage of barren stalks increased with the increases in plant population. Alessi and Power (1974) found that number of barren stalks increased and ear weight decreased as population increased. The grain yield had a tendency to increase with the increasing LAI whereas the yield significantly decreased with the increase in ears/plant as population decreased (Table 13). However, the negative effect of high populations on ears/plant, ear weight and bearing stalks was compensated by increased numbers of ears per unit area in producing higher yields at higher population.

Table 13. Correlation coefficients and predicted regression equations between various measurements in corn grown at Gainesville, FL in 1977.

Factors related (Dependent vs Independent)	Predicted regression equation		Correlation coefficient 'r' values
LAI vs plant population	$\hat{Y} = 0.65 + 0.71X$	(X=plants/m^2)	+0.72**
Ears/plant vs plant population	$\hat{Y} = 1.41 - 0.07X$	(X=plants/m^2)	-0.71**
Grain yield (kg/ha) vs LAI	$\hat{Y} = 6290 + 122X$	(X=plants/m^2)	+0.18
Grain yield (kg/ha) vs ears/plant	$\hat{Y} = 10185 - 3990\ X$	(X=ears/plant)	-0.51*

*, **, respectively, significant at 5% and 1% level

As plant population increases, the intraspecific competition between corn plants becomes more intense mainly for soil nutrients, water and light. Prine and Schroder (1964) stated that inadequate light is an important factor affecting ear number and grain yield per plant as population increases. Earley et al. (1966) found a significant decrease in grain, stover, protein and total oil in corn as light was decreased. Light was probably the main limiting factor which decreased the grain yield beyond 4.8 plants/m^2. It was found that the GDD or heat units required from planting to maturity (black layer development) were 2,515, 2,857 and 3,206, respectively, by Pioneer 3780, Pioneer 3369A and McNair 508 corn hybrids. These GDD values were very close to those (2,250, 2,380 and 3,180) obtained by Guilarte et al. (1975) for the respective hybrids at the same location earlier.

The above discussion suggests that for subtropical regions such as in north central Florida, early- and medium-maturing corn hybrids rather than late-maturing ones should be planted at high population.

Intercrops

Data on yields of intercrops along with corn yields at various treatment cominations are presented in Table 12. In general, the yields of all intercrops were very low indicating the tremendous shading effect of corn on them. Similar results were also obtained by Banta and Harwood (1975); Agboola and Fayemi (1971).

The comparative yields of peanuts and sweet potato as intercrops and sole crops are shown in Table 14. Early Bunch peanut yield was reduced from 3,360 kg/ha as pure stand to 600 kg/ha only as intercrop and thus the yield reduction was 82%. Similarly, Alabama Nugget sweet potato yield decreased from 12,770 kg/ha as pure stand to 2,230 kg/ha as intercrop indicating a yield loss of 83%. Red Jewel sweet potato produced 12,590 kg/ha as sole crop and 1,230 kg/ha as intercrop incurring 90% loss in root yield due to shading by adjacent corn plants. Pod yields of different peanut cultivars as intercrops and sole crops ranged, respectively, from 200 to 600 and 920 to 3,360 kg/ha.

Establishing proper plant stands of intercrops under the cover of corn canopy was difficult. The low yields of intercrops are attributed to insufficient light penetration through the corn canopy, poor weed control and inadequate control of insects and diseases. Leaf spot and spider mite (Tetranychus sp.) were serious problems. It was extremely difficult to reach the intercrop plants thickly covered by corn leaves with pesticides sprayed by mechanized commercial tractor sprayer. Proper pest control may be possible with indigenous methods of intercultural operations under labor-intensive cropping system rather than a high level of mechanization.

Dry matter production of soybean increased as leaf area increased up to a LAI of 3.2 and was directly proportional to the amount of light absorbed (Shibles and Weber, 1965) Streeter et al. (1975) stated that plants which were shaded for two weeks at various stages

Table 14. Comparative yield of peanut and sweet potato as intercrops in medium-maturing corn at 4.8 plants/m^2 and as pure stand at Gainesville, FL in 1977.

Intercrop		Intercrop yield	Yield as pure stand
Crops	Row spacing		
	(cm)	(kg/ha)	(kg/ha)
Florunner peanut	91	330	1900
Florunner peanut	46	310	1710
Dixie Runner peanut	91	210	920
Dixie Runner peanut	46	200	1200
Early Bunch peanut	91	280	1860
Early Bunch peanut	46	600	3360
Alabama Nugget sweet potato	91	2230	12770
Red Jewel sweet potato	91	1230	12590

of growth retained fewer flowers and pods than unshaded ones. Tao (1975) found that transpiration of soybean intercropped with corn was about 50% less than that of a pure stand. These evidences suggest that changes in the micro-environment under the corn canopy were responsible for low yields and poor performances of all the crops relay interplanted in corn.

Peanut

Pod yields of different peanut cultivars in different treatment combinations ranged from 160 to 630 kg/ha (Table 14). The highest yield was 630 kg/ha from Florunner planted in medium-maturing corn at 7.2 plants/m^2. On the average, Florunner produced 381 kg/ha of pods followed by Early Bunch (377 kg/ha) and Dixie Runner (303 kg/ha). Double rows 46 cm apart between corn rows produced comparatively higher pod yields in case of Early Bunch and Dixie Runner when compared to single row 91 cm apart; whereas it was the reverse in case of Florunner. The data on peanut yields did not indicate any trend as to whether higher corn populations reduced peanut yields or not. An IRRI (1973) report showed that seed yields of intercropped peanut decreased linearly when corn population was increased from 2 to 6 plants/m^2. Similar results were also reported by Koli (1975). In general, pod yields were very low probably due to very dry weather in the 1977 growing season which was unusual (Appendix Table 7), high incidence of weeds, leaf spot and spider mite. Varnell et al. (1976) found that competition from grasses in the second half of the season reduced peanut yields. At the time of germination of

peanut, it was observed that Early Bunch was damaged by raccoon more than Florunner and Dixie Runner probably due to either larger seed or better taste of the former than the others.

In an earlier study, Mauco (1977) found that pod yields and percentage of seed in pod were higher in Florunner than Dixie Runner peanuts interplanted in corn. In a range of corn population treatments and two interplanting dates, peanut produced higher yields at lowest population (2.4 plants/m^2) and in early interplanting. In this experiment, there were a large number of small and partially filled pods observed at harvest time in all three cultivars inside the corn indicating a wider range of pod maturity than commonly found, but there was no yield advantage when harvesting was delayed in a similar study earlier (Mauco, 1977). Duncan (1976) emphasized that a longer period will not in itself increase yield unless there are more fruits available at right time to be filled.

Initiation of flowering was delayed by 4 to 5 weeks in all the cultivars interplanted. The number of aborted flowers increased as a consequence of the shading effect of corn on peanut. Studies conducted by Hudgens and McCloud (1975) demonstrated that shading prior to flowering slowed vegetative growth while shading in the early flowering stage affected the distribution of pods around the main stem. Thus the main reason of such poor yield in peanut was probably due to shading by corn. However, the results suggest that peanut could be relay intercropped in corn provided adequate weed and pest management practices are carried out.

Pigeonpea and Sweet Potato

Pigeonpea and sweet potato were interplanted only in medium-maturing corn at 4.8 plants/m^2. Norman pigeonpea, Alabama Nugget and Red Jewel sweet potato produced, respectively, 8,560 kg/ha dry matter, 1,120 to 2,230 kg/ha of roots (Table 12). In an earlier study, maximum dry matter was obtained by Mauco (1977) from Norman pigeonpea interplanted in early-maturing corn at 2.4 plant/m^2 from a series of treatment combinations of early-, medium- and late-maturing corn hybrids at 2,4, 4.8 and 7.2 plants/m^2. Yields were drastically reduced by the late corn which produced higher LAI with resultant greater shading. Dalal (1974) pointed out that dry matter production and nutrients absorbed by pigeonpea intercropped with maize were significantly reduced as compared to pure stand. However, the dry matter production in pigeonpea suggests that it has a substantial potential to be used as a relay intercrop for forage in corn without much reduction in corn yield and particularly in areas where the pressure on arable land is so high that the farmers cannot afford additional land in growing forage. Moreover, pigeonpea is a good nitrogen fixer and could be used as a green manure crop if not grazed or cut for hay or silage.

Root yield of Alabama Nugget sweet potato was 81% higher than Red Jewel in medium-maturing corn whereas the latter produced 55% higher than the former in early-maturing corn. On the average, Alabama Nugget produced a higher yield (1,730 kg/ha) than Red Jewel (1,430 kg/ha) regardless of corn hybrid. This was probably

due to the fact that the former had better ability to establish seedlings and tolerate shade than the latter. This was again confirmed by their performance as pure stands where they did not differ much in yield (Table 14). Considering the higher bulk of carbohydrate production by sweet potato than the other intercrops, it should be an attractive component crop in intercropping to the hungry farmers mostly in the tropics.

Total Seasonal Yield (Main + Intercrop)

The total seasonal yield of corn hybrid and peanut was highest (8,030 kg/ha) from Pioneer 3369A corn at 4.8 plants/m^2 and Florunner peanut. In most of the treatment combinations, the combined yields of corn and intercrops were higher than those from pure stand of corn hybrids. The combined yield of Pioneer 3369A corn at 4.8 plants/m^2 and Norman pigeonpea (dry matter) as intercrop was 15,610 kg/ha. In case of corn and sweet potato, Alabama Nugget with Pioneer 3369A produced the maximum yield (9,830 kg/ha) followed by Pioneer 3780 and Alabama Nugget. These two treatment combinations produced more food per unit area per day than other combinations of corn and peanut. In general, the seasonal yields were much lower than those obtained in a similar study (Akhanda et al., 1978) the previous year probably due to weather difference (Appendix Table 7). However, the period that the land was occupied by the main crop and intercrop was about 60 to 70 days shorter as compared to double cropping of these crops. Many authors indicated yield advantages of intercropping over sequential double cropping in the tropics (Francis et al., 1976; Hildebrand, 1976; Harwood and Price, 1976; and Andrews and Kassam,

1976) and which was possible in labor-intensive cropping system under low level of mechanization but may not happen in capital intensive, high level of mechanization.

Appraisal of Intercropping

Until the advent of widespread use of tractor and mechanization in the developed countries, intercropping, especially relay intercropping, was extensively practiced. In many areas of the tropical world, intercropping is widely used today. However, intercropping has usually been most successful where cultivation and other production practices are done by hand or with the use of draft animal.

Based on the experiences in this study, it would be easier and have greater chance of success if two warm season crops were double cropped, particularly in condition of high level mechanization, during the warm season instead of being planted as a relay intercrop. Relay intercropping does have a definite advantage over double cropping as it allows growing two crops in a shorter period of time and allows more time for a third or fourth crop during the crop year. However, intercropping always has the disadvantage that one or both crops may produce less because of interspecific competition. In the corn-intercrop system used, the corn would have to be grown at populations lower than needed for maximum grain yields if a successful intercrop is to be grown in the corn. The intercrop would not be as productive as if it was not grown in corn.

However, intercropping under mechanization can be successful if one is prepared to take somewhat reduced yields which are

inherent in the system. Crop cultivars will need to be carefully selected or more likely especially bred for use in intercropping. Better weed control for both crops by herbicides will be needed. Energy use should be less under intercropping than double cropping. Management will have to be geared to intercropping. As an instance, the performance of intercrops would have been better if corn plants could have been removed for silage without damaging the intercrops. Different uses of crops under intercropping might also be desirable. Some of the tandard corn-pigeonpea plots would have made a lot of feed if both crops had been chopped and ensiled in late September or early October.

Machinery would have to be developed which could allow easier passage in intercrops for cultivating, harvesting and applying pesticides. Increased cost of nitrogen fertilizer could make growing a high yielding legume as an intercrop more practical. Researchers and farmers are encouraged to develop ingenious new intercropping ideas that can make intercropping successful under mechanization.

In a labor-intensive cropping system in the developing countries in the tropics the better combinations with corn found in this research are expected to produce better results than it did in Florida.

SUMMARY AND CONCLUSIONS

Several field experiments were conducted at the University of Florida, Gainesville, in 1976 and 1977. The objectives of these investigations were to (1) select soybean cultivars suitable for use as late-planted second cr in a warm season double cropping system, (2) find the influence of row widths and plant populations on the seed yields and yield components of sorghum and sunflower and (3) search the possibility of intercropping peanut, pigeonpea and sweet potato in early-, medium- and late-maturing corn hybrids at different plant populations under high level of mechanization. Either a randomi d complete block or a split-plot design was used in various experiments.

In 1976, 129 soybean cultivars and breeding lines were planted in 41-cm rows on July 20 (1st planting) and August 6 (2nd planting) while the first and second plantings of 84 selected lines were made, respectively, on July 15 and August 3 in 1977. Wide ranges of expression for several agronomic traits were found in both planting dates in both years. In August 3 and 6 plantings, length of life cycle, height of lowest pod, plant height and seed yield were generally less than July 15 and 20 plantings. The period from planting to flowering was found to be the most important factor affecting the length of life cycle of soybean. This period ranged

from 37 to 57 and 31 to 50 in 1976 and 42 to 59 and 30 to 50 days in 1977. The second important phase affecting the life cycle was the period from the end of flowering to physiological maturity (R_7) which differed by more than three weeks among cultivars. Plant height at maturity and bottom pod height ranged, respectively, from 27 to 112 and 24 to 94 and 0 to 33 and 0 to 30 cm for the first and second plantings. In the first planting of 1976 and 1977, respectively, 42 out of 129 and 50 out of 84 produced pods at 15 cm or above whereas in second planting, 12 of 129 produced pods at 15 cm and above, but none in 1977, though there were 12 lines having lowest pods at 12 cm or above.

The life cycle ranged from 88 to 116 and 83 to 106 days, respectively, for July and August plantings. To complete the life cycle, July 15 planting required 3,047 GDD whereas August 3 planting needed 2,501 GDD. In the first and second planting in 1976, respectively, 122 and 110 out of 129 lines physiologically matured before November 10. But in 1977, all except the Jupiter selection (Group IX) in second planting reached R_7 in the first week of November. Late-planted soybeans which mature during the first week of November are likely to escape frost damage in Florida and other subtropical regions.

Seed yields were found to be positively correlated with the length of flowering period ('r' = 0.35** to 0.44**), pod filling period ('r' = 0.35** to 0.49**), plant height ('r' = 0.25* to 0.27*) and length of life cycle ('r' = 0.34* to 0.37*). Similarly, bottom

pod height had a strong direct relationship with planting to flowering days ('r' = 0.40** to 0.54**), plant height at flowering ('r' = 0.59** to 0.65**) and maturity ('r' = 0.61** to 0.80**) and a high negative correlation with pod filling period ('r' = -0.39** to -0.46**).

Among cultivars, seed yield ranged from 2,260 to 4,550 and 2,060 to 3,660 kg/ha in the first planting of 1976 and 1977, respectively. The ranges in the second planting were, respectively, from 820 to 3,130 and 1,080 to 2,410 kg/ha. Only F73-9564 produced the highest yield in the first planting of both years. The maximum yields for the second planting were, from F74-2155 and F74-3514, respectively, in 1976 and 1977. The average of both years was highest (2,380 kg/ha) from F74-3510. The ten most promising lines were altogether different in first and second plantings except F72-5823 which consistently gave higher yield in both plantings and both years. Among the varieties used as control, Jupiter selection produced the most and Santa Rosa least in the first planting whereas the latter produced most and the former least in second planting. Neither the earliest nor the latest maturing types among cultivars used were superior in seed yield. Many new breeding lines produced significantly higher yield as compared to named varieties presently used for commercial planting.

Taylor-Evans brand Bird-A-Boo II and Pioneer brand B-815 sorghum cultivars were planted on March 22, 1977, at 41, 61 and 91 cm row widths and 20, 30 and 40 plants/m^2. With increasing plant population, LAI and panicle length, respectively, increased and decreased

consistentl plant height increased from 20 to 30 plants/m^2 and remained the same with further increase in population; whereas the grain yield significantly increased from 20 to 30 plants/m^2 and then decreased sharply. Pioneer B-815 and T-E Bird-A-Boo II produced, respectively, 3,930 and 3,640 kg/ha with a rate of 3.88 g/m^2 day^{-1}. For completing the life cycle (from planting to black layer development), the former required 1,700 GDD as compared to 1,543 GDD needed by the latter.

Grain yield was highest (4,130 kg/ha) from 30 plants/m^2 followed by 3,680 kg/ha from 40 plants/m^2 and the lowest (3,550 kg/ha) from the lowest plant population of 20 plants/m^2. Regression analysis revealed a significant curvilinear relationship between grain yield and increasing plant population with associated increasing LAI. The grain yield increased at a rate of 132 kg/ha for each increase of one plant/m^2 from 20 to 30 plants/m^2 and then decreased by two kg/ha for each further increase of one plant/m^2 ($\hat{Y} = 1759 + 132X - 2X^2$). This relationship was significant with R^2 value of 0.82*. This was attributed to the increased competition between sorghum plants for water and nutrients with increasing plant population and relative decrease in the efficiency of unit leaf area for photosynthesis due to mutual shading under increased LAI at higher population. Panicle length showed a decreasing trend with increasing row width but the changes in row width did not make any significant difference in grain yield. The results indicated that sorghum has an amazing capacity to adjust itself in a wide range of row width and produce high yield by intercompensating among yield components, head/unit area and seed per head in particular.

Three cultivars of sunflower, Interstate 891, Pacific Oilseeds Sun-Hi 304 and Cargill 204 were planted at 41, 61 and 91 cm row widths at 4, 6 and 8 plants/m^2 on February 17, 1977. The plant height and LAI increased significantly from 163 cm and 3.35 at 4 plants/m^2 to 183 cm and 7.49 at 8 plants/m^2, respectively, with 'r' values of 0.75** and 0.94**. Seed yield was highest (2,750 kg/ha) at the highest population. Seed yields were increased by 167 and 122 kg/ha, respectively, for each increase of one plant/m^2 and one LAI unit with correlation coefficients of 0.66** and 0.85**. The diameter of stem and head and 100-seed weight sharply decreased from 2.62 and 21 cm and 5.14 gm at 4 plants/m^2 to, respectively, 1.96 and 15 cm and 4.34 gm at 8 plants/m^2 with 'r' values of -0.84**, -0.96** and -0.64** between them indicating a serious intraspecific competition for nutrients, water and light with increasing population.

Interstate 891 produced the highest yield (2,670 kg/ha) as well as highest total oil (1,220 kg/ha). Oil of all the cultivars contained about 91% unsaturated fatty acids. Neither the row width nor its interaction with populations had any significant effect on yield.

In the intercropping study, Pioneer brand 3780, Pioneer brand 3369A and McNair 508, early-, medium-, and late-maturing corn hybrids, were planted on March 11 at populations of 2.4, 4.8 and 7.2 plants/m^2. 'Florunner', 'Dixie Runner' and 'Early Bunch' peanut, 'Norman pigeonpea, 'Alabama Nugget' and 'Red Jewel' sweet potato were planted at lay-by (last cultivation). All intercrops, except pigeonpea, were also planted as pure stands.

Intercrops did not affect corn yield. Increasing plant population enhanced corn yield from 2.4 to 4.8 plants/m^2. McNair 508

produced most (7,240 kg/ha) at 4.8 plants/m^2 followed by Pioneer 3369A (7,150 kg/ha) at 4.8 plants/m^2 and Pioneer 3780 (6,970 kg/ha) at 7.2 plants/m^2 with no difference among them. The grain yields from Pioneer 3780 and Pioneer 3369A at 4.8 and 7.2 plants/m^2 were significantly higher than those at 2.4 plants/m^2 with no statistical yield difference at 4.8 and 7.2 plants/m^2. Corn grain yields of different treatment combinations indicated that Pioneer 3369A at 4.8 plants/m^2 with Florunner peanut at 46 cm row spacing as intercrop produced the highest amount of grain but this yield was not significantly different from 17 other treatment combinations out of 24. Plant population and grain yield of corn had a curvilinear relationship ($\hat{Y} = 5820 + 2446X - 299X^2$; $R^2 = 0.64^{**}$). With the increasing plant population LAI increased ($\hat{Y} = 0.66 + 0.71X$; $r = 0.72^{**}$) and the ears/plant decreased ($\hat{Y} = 1.41 - 0.70X$; $r = 0.71^{**}$) significantly.

Yields of all the intercrops were low indicating the tremendous shading effect of corn. Forage and/or seed yields of intercrops were usually highest in early-maturing corn at lowest population. Peanut yields were reduced from 3,360 kg/ha as pure stand to 600 kg/ha as intercrop whereas sweet potato yields decreased from 12,700 kg/ha to 2,230 kg/ha. The sweet potato root production was only 10 and 17.5% of sole crop for Red Jewel and Alabama Nugget, respectively. The beginning of flowering in all intercrops was delayed by three to five weeks as compared to sole planting in pure stands. In medium- and late-maturing corn at high plant population many peanut plants died after excellent early stands. Establishing the plant stands of intercrops and controlling insects, diseases and weeds

were found to be extremely difficult under the high level of mechanization.

From the results obtained in this research, the following conclusions may be emphasized:

1. Potential genetic materials are available for developing late-planted soybean cultivars which are both productive and have a satisfactory agronomic plant type. Correlation studies and growth analysis indicated that the growth patterns of soybean could be engineered to provide a more efficient seed-producing plant by manipulating these genetic materials through breeding program.

2. The breeding lines, F73-9564, F71-1606 and F72-5823, have potential for July planting in double cropping systems in the tropical and subtropical regions. In late-planting, they offer promise for higher yields than the varieties available for normal planting. Similarly, F74-3510, F74-9458 and F74-2122 can be used for later planting in early August. F72-5823 might do equally well in both late-July and early-August plantings.

3. As the planting is delayed the soybean plants become smaller. Therefore, soybean as a second crop in warm season double cropping systems should be planted in narrow rows and at higher population.

4. Because late-planted soybeans may be damaged by frost, cultivars and planting dates should be selected so as to insure maturity before November 10 in north Florida and similar climatic regions.

5. Sorghum can produce a satisfactory yield at a wide range of row width and plant population by intercompensating among yield

components, particularly head/unit area and seeds/head. This elastic characteristic of sorghum as to variable row widths should make it an important component in alternate row intercropping systems.

6. Sorghum should be planted at a population of 30 plants/m^2 at any convenient row spacing up to 91 cm apart. Pioneer B-815 seemed to have higher yield potential than Taylor-Evans Bird-A-Boo II.

7. Interstate 891 sunflower cultivar should be planted at populations of about 8 plants/m^2 with any spacing between rows that is convenient up to 91 cm apart under tropical conditions.

8. Sunflower being highly phototropic has a peculiar process of 'nutation' which suggests that it would use the solar radiation more efficiently than others in a mixed community of plant species. Because of this habit sunflower should be an important component in mixed cropping or alternate row intercropping systems in the tropics.

9. Considering its productivity and edible oil quality, sunflower must be an alternate oil-seed crop in multiple cropping systems in tropical countries where the edible oil shortage is more acute.

10. Early- and medium-maturing corn hybrids rather than late-maturing ones should be planted at high population but not exceeding 4.8 plants/m^2.

11. Selected cultivars of peanut, pigeonpea and sweet potato may be intercropped in early- and medium-maturing corn hybrids at plant populations not exceeding 4.8 plants/m^2 in a labor-intensive cropping system under low level of mechanization.

12. Establishing intercrop stands and control of weeds and pests are difficult under high level of mechanization and under such

conditions it would be easier and have greater chance of success if two warm season crops are double cropped during the warm season instead of being planted as a relay intercrop.

13. Intercropping has the disadvantage that one or both crops may produce less because of interspecific competition. However, the energy use should be less under intercropping than double cropping with the energy input-output ratio higher in intercropping.

14. To make intercropping successful under high level of mechanization, machinery would have to be developed which could allow easier passage in intercrops for cultivating, harvesting and applying pesticides. Similarly, crop cultivars will need to be carefully selected or specially bred for use in intercropping.

15. In labor-intensive cropping systems in the developing countries in the tropics where cultivation and other production practices are done by hand or with the use of draft animals, intercropping peanut, pigeonpea and sweet potato in corn is expected to produce better results than it did in Florida.

APPENDIX TABLES

Appendix Table 1. The dates (month-day) that flowering started and ended, pod filling started, physiologically matured and were ready to harvest for 129 soybean cultivars or lines planted on two dates at Gainesville, FL in 1976.

	July 20 Planting					August 6 Planting				
Cultivar or line	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest
Series 23										
F74-2064	8-28	9-19	9-10	10-30	11-10	9-6	10-2	9-21	11-4	11-13
F74-2080	8-28	9-18	9-10	11-1	11-10	9-7	10-2	9-22	11-3	11-12
F74-2023	8-29	9-22	9-12	10-30	11-10	9-10	10-6	9-25	11-7	11-17
F74-1993	8-29	9-19	9-12	10-28	11-5	9-11	10-9	9-26	11-4	11-11
F74-2774	8-30	9-19	9-12	10-29	11-9	9-6	9-27	9-19	11-2	11-11
F74-2678	8-30	9-26	9-13	10-30	11-10	9-10	10-7	9-24	11-4	11-11
F74-2001	8-30	9-22	9-13	10-25	11-5	9-10	10-8	9-25	11-5	11-12
F74-2203	8-30	9-19	9-12	10-24	11-8	9-12	10-7	9-26	11-4	11-12
F74-1970	8-30	9-22	9-13	10-27	11-4	9-10	10-6	9-25	11-4	11-11
F74-2432	8-30	9-24	9-14	11-1	11-10	9-12	10-11	9-25	11-10	11-20
F74-1979	8-30	9-19	9-12	10-25	11-3	9-10	10-5	9-25	11-3	11-10
F74-2684	8-30	9-26	9-14	10-30	11-10	9-11	10-11	9-25	11-7	11-17
F74-2215	8-30	9-19	9-12	10-23	11-5	9-12	10-9	9-26	11-1	11-11
F74-2150	8-30	9-25	9-14	10-31	11-9	9-11	10-12	9-27	11-9	11-18
F74-2130	8-30	9-23	9-13	10-31	11-10	9-11	10-9	9-25	11-8	11-19
F74-2685	8-31	9-23	9-15	11-2	11-10	9-10	10-8	9-25	11-7	11-13
F74-1976	8-31	9-28	9-14	11-2	11-11	9-12	10-12	9-28	11-10	11-20
F74-2716	9-1	9-23	9-14	11-5	11-11	9-10	10-7	9-25	11-10	11-21
F74-2068	9-2	9-25	9-15	10-30	11-7	9-12	10-12	9-27	11-5	11-12
F74-2128	9-2	9-28	9-16	11-3	11-11	9-14	10-13	9-30	11-11*	11-21
F74-2122	9-2	9-26	9-15	11-1	11-10	9-14	10-12	9-29	11-10	11-20
F74-2640	9-3	9-24	9-17	11-2	11-9	9-13	10-9	9-27	11-9	11-16
Series 24										
F73-7405	8-27	9-16	9-9	10-24	11-9	9-7	10-2	9-22	11-2	11-12
F73-9769	8-27	9-22	9-11	10-22	11-8	9-5	10-3	9-18	11-1	11-11

Appendix Table 1 - Continued

Cultivar or line	July 20 Planting					August 6 Planting				
	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Psysiological Maturity (R7)	Ready for Harvest
Series 24										
F73-9581	8-27	9-24	9-12	10-16	11-7	9-7	10-4	9-22	10-28	11-9
F73-9793	8-28	9-20	9-10	10-17	11-3	9-7	10-3	9-20	11-1	11-9
F73-9772	8-29	9-18	9-10	10-23	11-6	9-9	10-4	9-24	11-4	11-13
F70-3198	8-29	9-21	9-12	10-28	11-10	9-8	10-3	9-18	11-3	11-13
F73-8451	8-30	9-22	9-13	10-24	11-9	9-9	10-6	9-25	11-6	11-14
F73-9751	8-30	9-19	9-11	10-25	11-4	9-12	10-5	9-26	11-5	11-14
F73-9789	8-31	9-19	9-11	10-26	11-6	9-13	10-6	9-26	11-5	11-13
F74-3491	8-31	9-25	9-14	10-29	11-10	9-11	10-9	9-25	11-3	11-12
F74-3489	9-31	9-29	9-16	11-2	11-11	9-10	10-16	9-24	11-9	11-20
F74-3493	8-31	9-28	9-15	11-2	11-10	9-12	10-12	9-26	11-9	11-18
F73-8346	9-1	9-25	9-14	11-3	11-9	9-12	10-10	9-27	11-9	11-16
F74-3510	9-1	9-30	9-15	11-2	11-10	9-12	10-15	9-28	11-8	11-19
F72-4163	9-1	9-26	9-15	10-31	11-10	9-11	10-7	9-25	11-5	11-14
F73-9613	9-1	9-29	9-16	10-20	11-8	9-12	10-10	9-25	10-28	11-10
F72-3984	9-2	9-26	9-16	10-28	11-10	9-14	10-10	9-29	11-8	11-17
F72-4798	9-2	9-26	9-14	10-30	11-10	9-15	10-13	10-1	11-9	11-19
F73-8384	9-2	9-24	9-15	10-31	11-8	9-14	10-10	9-29	11-11*	11-21
F73-9335	9-4	9-29	9-21	11-1	11-8	9-13	10-11	9-27	11-5	11-12
F72-5823	9-4	10-3	9-23	11-6	11-12	9-14	10-15	9-30	11-11*	11-20
F72-4637	9-4	10-1	9-19	11-1	11-9	9-16	10-11	10-4	11-14*	11-23
Series 25										
F73-9797	8-28	9-22	9-12	11-1	11-9	9-6	10-2	9-21	11-10	11-19
F72-4028	8-29	9-22	9-13	10-26	11-9	9-9	10-6	9-24	11-6	11-15
F73-9569	8-29	9-23	9-12	10-24	11-8	9-9	10-8	9-23	10-31	11-11
F73-9583	8-29	9-20	9-12	10-25	11-5	9-8	10-4	9-22	11-2	11-10
F73-9341	8-30	9-24	9-14	10-31	11-11	9-10	10-10	9-26	11-8	11-21

Appendix Table 1 - Continued

	July 20 Planting					August 6 Planting				
Cultivar or line	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest
Series 25										
F73-9758	8-30	9-22	9-13	10-22	11-3	9-11	10-6	9-25	11-4	11-18
F73-9787	8-31	9-22	9-13	10-27	11-5	9-12	10-7	9-26	11-5	11-14
F73-8414	8-31	9-23	9-13	10-29	11-11	9-11	10-8	9-25	11-7	11-16
F71-1606	8-31	9-26	9-14	10-28	11-10	9-10	10-9	9-25	11-5	11-14
F73-8338	8-31	9-23	9-13	10-26	11-6	9-12	10-11	9-25	11-4	11-12
F73-9733	8-31	9-28	9-15	11-3	11-10	9-11	10-10	9-25	11-9	11-18
D73-9358	9-1	9-27	9-15	11-3	11-12	9-12	10-9	9-26	11-9	11-18
F67-1634	9-1	9-24	9-15	10-31	11-9	9-11	10-8	9-25	11-5	11-13
F73-9780	9-1	9-22	9-14	10-21	11-3	9-12	10-5	9-25	11-2	11-11
F73-9564	9-1	9-26	9-16	10-31	11-9	9-12	10-10	9-26	11-8	11-16
D73-9360	9-2	9-30	9-16	11-4	11-12	9-13	10-12	9-29	11-8	11-19
F73-9728	9-2	9-28	9-17	11-3	11-11	9-12	10-8	9-28	11-9	11-17
F73-9723	9-3	9-30	9-17	11-1	11-10	9-12	10-11	9-27	11-8	11-18
F73-9576	9-3	10-1	9-18	10-29	11-10	9-14	10-12	9-29	11-5	11-14
F74-3514	9-4	10-2	9-18	11-4	11-12	9-15	10-14	10-2	11-10	11-22
F73-9391	9-6	10-2	9-24	11-5	11-12	9-17	10-14	10-4	11-11*	11-21
F73-9437	9-6	10-3	9-25	11-5	11-12	9-16	10-15	10-2	11-10	11-20
Series 26										
F75-7876	8-26	9-19	9-11	10-31	11-9	9-6	10-2	9-20	11-5	11-13
F75-7131	8-27	9-15	9-8	10-29	11-10	9-7	10-1	9-20	11-5	11-13
F73-7418	8-28	9-17	9-9	10-17	11-10	9-8	10-6	9-23	11-3	11-13
F75-7180	8-29	9-24	9-12	10-31	11-10	9-10	10-7	9-24	11-4	11-15
F75-6809	8-29	9-29	9-13	10-30	11-10	9-9	10-10	9-24	11-5	11-14
F75-7201	8-29	9-25	9-12	10-31	11-9	9-10	10-9	9-26	11-6	11-16
F75-6834	8-29	9-25	9-12	10-29	11-10	9-10	10-8	9-24	11-5	11-14
F75-7198	8-30	9-24	9-13	10-30	11-10	9-9	10-8	9-24	11-6	11-15

Appendix Table 1 - Continued

	July 20 Planting					August 6 Planting				
Cultivar or line	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest
Series 26										
F75-7211	8-30	9-26	9-13	10-30	11-8	9-12	10-12	9-26	11-5	11-13
F75-7147	8-30	9-25	9-13	10-31	11-6	9-12	10-12	9-26	11-6	11-15
F75-7941	8-31	9-23	9-13	11-3	11-10	9-11	10-9	9-25	11-10	11-19
F72-4631	9-3	10-4	9-19	11-2	11-9	9-14	10-14	9-30	11-10	11-17
F74-2155	9-3	10-2	9-19	11-3	11-11	9-14	10-15	9-30	11-11*	11-21
F75-9179	9-4	10-3	9-25	11-6	11-12	9-15	10-15	10-2	11-11*	11-21
F75-9189	9-5	10-3	9-25	11-4	11-10	9-15	10-15	10-1	11-7	11-15
F75-9194	9-5	10-3	9-26	11-3	11-10	9-15	10-14	10-2	11-10	11-18
F75-9187	9-5	10-4	9-25	11-5	11-11	9-14	10-15	9-30	11-10	11-19
F73-9351	9-5	10-1	9-24	11-3	11-9	9-16	10-14	10-4	11-11*	11-21
F75-9204	9-6	10-5	9-25	11-5	11-11	9-15	10-16	10-1	11-10	11-18
F75-9207	9-8	10-3	9-28	11-9	11-16	9-17	10-16	10-6	11-12*	11-25
Series 27										
F75-7220	8-27	9-26	9-12	10-31	11-9	9-8	10-6	9-22	11-4	11-14
F75-6923	8-28	9-18	9-10	10-26	11-8	9-7	10-2	9-21	11-1	11-10
F75-6867	8-29	9-22	9-12	10-22	11-10	9-11	10-9	9-24	11-3	11-12
F75-6969	8-29	9-21	9-13	10-25	11-8	9-9	10-6	9-24	10-30	11-9
F75-6863	8-30	9-20	9-10	10-25	11-9	9-12	10-8	9-25	11-4	11-11
F75-6934	8-30	9-26	9-13	10-24	11-7	9-11	10-11	9-24	11-3	11-11
F75-6920	8-30	9-26	9-13	10-27	11-8	9-12	10-10	9-25	11-4	11-12
F75-6893	8-30	9-21	9-11	10-23	11-8	9-12	10-9	9-25	10-31	11-10
F75-7085	8-30	9-25	9-13	10-19	11-9	9-11	10-8	9-24	10-31	11-12
F75-8721	8-30	9-27	9-12	11-2	11-10	9-11	10-11	9-25	11-8	11-17
F75-7089	8-30	9-23	9-13	10-22	11-5	9-12	10-11	9-25	11-2	11-12
F75-6885	8-31	9-27	9-14	10-29	11-9	9-13	10-12	9-27	11-7	11-15
F75-7128	8-31	9-27	9-13	10-19	11-9	9-11	10-10	9-24	10-31	11-11

Appendix Table 1 - Continued

Cultivar or line	July 20 Planting: Flowering Started	July 20 Planting: Flowering Ended	July 20 Planting: Beginning of Pod Filling (R5)	July 20 Planting: Physiological Maturity (R7)	July 20 Planting: Ready for Harvest	August 6 Planting: Flowering Started	August 6 Planting: Flowering Ended	August 6 Planting: Beginning of Pod Filling (R5)	August 6 Planting: Physiological Maturity (R7)	August 6 Planting: Ready for Harvest
Series 27										
F75-7093	9-31	9-23	9-13	10-23	11-8	9-12	10-11	9-25	11-3	11-12
F75-7041	8-31	9-24	9-13	10-21	11-9	9-11	10-11	9-25	10-31	11-11
F75-8742	8-31	9-26	9-13	11-1	11-9	9-12	10-11	9-27	11-7	11-16
F75-7102	8-31	9-23	9-13	10-20	11-7	9-11	10-11	9-24	10-31	11-10
F73-9741	8-31	9-20	9-13	10-24	11-6	9-1[illegible]	10-5	9-25	11-3	11-11
F75-8756	9-2	9-24	9-15	11-2	11-12	9-14	10-12	9-29	11-8	11-19
F73-9415	9-5	10-3	9-25	11-4	11-11	9-15	10-13	10-2	11-10	11-21
Series 28										
F73-7418	8-29	9-15	9-10	10-19	11-11	9-9	10-4	9-22	11-2	11-10
F71-1606	8-30	9-18	9-11	10-28	11-10	9-9	10-5	9-24	10-30	11-9
F73-9341	8-30	9-21	9-13	11-1	11-10	9-9	10-6	9-24	11-6	11-12
F73-9741	8-31	9-20	9-13	10-25	11-8	9-9	10-5	9-23	11-1	11-10
F73-9564	8-31	9-21	9-14	11-2	11-9	9-10	10-5	9-25	11-2	11-12
F69-2185	9-2	9-26	9-14	11-5	11-12	9-11	10-5	9-24	11-7	11-17
F73-9351	9-3	9-28	9-17	11-2	11-9	9-16	10-14	10-3	11-10	11-18
F73-9415	9-5	10-2	9-24	11-6	11-11	9-15	10-14	10-2	11-10	11-18
F73-9458	9-6	10-3	9-26	11-6	11-11	9-15	10-14	10-2	11-10	11-18
F73-9458	9-6	10-3	9-26	11-6	11-11	9-15	10-14	10-2	11-10	11-18
OS 14	9-6	10-4	9-26	11-6	11-12	9-15	10-15	10-3	11-11*	11-18
F67-5132	9-11	10-6	9-28	11-6	11-13	9-23	10-15	10-8	11-14*	11-23
F72-5540*	9-14	10-9	10-3	11-11*	11-19	9-25	10-18	10-12	11-18*	11-26
F72-5545*	9-14	10-9	10-1	11-11*	11-19	9-25	10-18	10-13	11-19*	11-26
F69-2143*	9-15	10-9	10-2	11-12*	11-20	9-25	10-18	10-12	11-19*	11-26
F72-5532*	9-15	10-9	10-2	11-13*	11-20	9-25	10-18	10-14	11-19*	11-27
G72-279*	9-15	10-9	10-1	11-12*	11-19	9-25	10-18	10-12	11-19*	11-27
G72-312*	9-15	10-10	10-2	11-12*	11-20	9-25	10-18	10-12	11-19*	11-27

Appendix Table 1 - Continued

Cultivar or line	July 20 Planting: Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest	August 6 Planting: Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest
Control										
Cobb	8-30	9-19	9-13	11-2	11-11	9-9	10-8	9-24	11-9	11-17
Vicoja	9-2	9-27	9-16	10-27	11-5	9-13	10-11	9-28	11-6	11-13
Santa Rosa	9-4	10-1	9-20	11-1	11-8	9-15	10-15	10-1	11-10	11-18
Miniera	9-4	9-28	9-17	10-31	11-8	9-15	10-13	9-30	11-10	11-19
UFV-1	9-8	10-2	9-25	11-6	11-13	9-19	10-16	10-9	11-12*	11-22
Jupiter Sel.	9-14	10-9	9-30	11-12*	11-19	9-24	10-18	10-11	11-20*	11-26

*Freezing temperatures occurred November 6 and 9 and may have influenced the date of physiological maturity when physiological maturity occurred after November 10.

Appendix Table 2. The dates (month-day) that flowering started and ended, pod filling started, physiologically matured and were ready to harvest for 84 soybean cultivars or lines planted on two dates at Gainesville, FL in 1977.

	July 15 Planting					August 3 Planting				
Cultivar or line	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest
Series 23										
F74-2080	8-26	9-28	9-15	10-27	11-10	9-6	10-8	9-23	11-1	11-14
F74-2128	9-1	10-3	9-19	10-29	11-15	9-13	10-10	9-30	11-5	11-19
F74-2068	8-30	10-2	9-17	10-26	11-7	9-11	10-9	9-26	10-31	11-12
F74-2684	8-29	10-1	9-15	10-28	11-13	9-9	10-10	9-26	11-2	11-16
F74-2150	8-30	10-2	9-16	10-28	11-10	9-8	10-10	9-26	11-2	11-18
F74-2122	9-1	10-4	9-18	10-28	11-15	9-12	10-10	9-29	11-5	11-19
F74-2023	8-26	9-29	9-14	10-25	11-13	9-10	10-9	9-26	11-4	11-21
F74-1993	8-29	9-29	9-13	10-23	11-7	9-9	10-8	9-25	10-31	11-15
F74-1979	8-29	9-29	9-15	10-24	11-7	9-9	10-7	9-26	10-29	11-12
F74-2685	8-30	10-3	9-17	10-31	11-14	9-10	10-9	9-25	11-3	11-19
F74-2001	8-29	10-1	9-16	10-24	11-4	9-10	10-7	9-27	11-1	11-13
F74-2215	8-30	9-30	9-16	10-22	11-5	9-11	10-7	9-25	10-28	11-9
F74-1976	8-30	10-3	9-17	10-29	11-15	9-12	10-12	9-28	11-5	11-21
F74-2203	8-30	9-29	9-14	10-24	11-9	9-11	10-8	9-26	10-30	11-15
F74-2640	9-1	10-3	9-19	11-2	11-15	9-12	10-9	9-29	11-5	11-18
F74-2774	8-29	9-30	9-17	10-27	11-18	9-5	10-3	9-21	10-29	11-11
Series 24										
F74-3489	8-29	10-4	9-17	10-31	11-15	9-9	10-12	9-26	11-5	11-19
F72-4637	9-1	10-5	9-21	10-29	11-9	9-15	10-14	10-2	11-4	11-17
F74-3493	8-30	10-4	9-17	10-31	11-15	9-11	10-12	9-27	11-7	11-20
F72-5823	9-2	10-9	9-22	11-3	11-14	9-14	10-14	10-1	11-9	11-18
F74-3491	8-30	10-2	9-18	10-28	11-14	9-11	10-10	9-26	11-1	11-18

Appendix Table 2 - Continued

	July 15 Planting					August 3 Planting				
Cultivar or line	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest
Series 24										
F73-8384	8-30	10-3	9-17	11-1	11-4	9-12	10-11	9-27	11-7	11-18
F73-8346	8-30	10-2	9-16	10-29	11-10	9-9	10-9	9-26	11-4	11-17
F72-4163	8-29	10-2	9-16	10-26	11-9	9-10	10-9	9-27	11-1	11-15
F72-4798	8-30	10-2	9-15	10-27	11-10	9-12	10-11	9-28	11-2	11-18
F72-3984	8-30	9-29	9-13	10-26	11-10	9-12	10-10	9-27	11-1	11-17
F74-3510	8-28	10-5	9-17	10-28	11-11	9-10	10-12	9-28	11-3	11-16
F73-9335	8-30	10-4	9-19	10-29	11-10	9-12	10-12	9-28	11-5	11-17
F73-9613	8-29	10-1	9-16	10-24	11-7	9-12	10-8	9-27	10-30	11-11
F73-9789	8-31	9-30	9-17	10-26	11-9	9-11	10-7	9-26	11-1	11-17
Series 25										
F73-9341	8-28	10-1	9-14	10-28	11-11	9-8	10-8	9-25	11-2	11-17
F73-9583	8-27	9-30	9-13	10-28	11-10	9-5	10-6	9-23	10-31	11-11
F73-9564	8-30	10-5	9-18	11-1	11-10	9-9	10-10	9-27	11-4	11-16
F74-3514	9-2	10-9	9-19	10-31	11-15	9-13	10-14	9-30	11-6	11-20
F73-9733	8-30	10-4	9-18	11-1	11-15	9-10	10-11	9-28	11-6	11-19
F73-9723	9-1	10-8	9-18	11-2	11-15	9-12	10-12	9-28	11-4	11-20
F73-9728	8-30	10-5	9-18	11-2	11-16	9-11	10-13	9-27	11-4	11-18
F73-9797	8-27	9-28	9-14	10-30	11-9	9-5	10-3	9-22	11-1	11-14
F73-9391	9-5	10-8	9-24	11-3	11-15	9-16	10-13	10-3	11-8	11-19
F73-9358	8-29	10-3	9-17	11-1	11-14	9-10	10-10	9-27	11-7	11-19
F71-1606	8-29	10-1	9-14	10-28	11-16	9-9	10-7	9-24	11-2	11-18
F73-9360	8-29	10-4	9-18	11-2	11-15	9-11	10-11	9-28	11-7	11-19
F73-9758	8-27	9-28	9-12	10-23	11-8	9-9	10-6	9-23	10-28	11-11
F73-9569	8-28	9-30	9-15	10-27	11-10	9-7	10-6	9-23	10-30	11-13

Appendix Table 2 - Continued

Cultivar or line	July 15 Planting					August 3 Planting				
	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest
Series 26										
F75-9207	9-7	10-12	9-28	11-5	11-15	9-16	10-20	10-6	11-11	11-18
F75-7941	8-27	10-2	9-14	10-28	11-11	9-9	10-11	9-27	11-5	11-19
F74-2155	8-31	10-4	9-19	10-31	11-13	9-13	10-11	9-30	11-4	11-18
F75-7147	8-29	10-3	9-15	10-26	11-6	9-10	10-10	9-25	11-1	11-17
F75-7180	8-28	9-28	9-13	10-25	11-11	9-9	10-9	9-23	10-31	11-17
F75-9194	9-4	10-10	9-25	11-2	11-15	9-14	10-17	10-3	11-7	11-17
F75-9204	9-5	10-12	9-26	11-2	11-15	9-15	10-20	10-5	11-9	11-17
F75-7211	8-29	10-4	9-15	10-25	11-7	9-10	10-10	9-25	10-31	11-15
F73-7418	8-28	9-29	9-13	10-23	11-12	9-7	10-7	9-25	10-31	11-15
F75-9179	8-30	10-9	9-23	11-3	11-18	9-14	10-18	10-3	11-9	11-19
F75-7201	8-29	10-2	9-14	10-26	11-10	9-10	11-10	9-24	11-1	11-15
F75-6834	8-29	10-1	9-13	10-25	11-11	9-10	10-11	9-25	11-4	11-18
F75-9205	9-6	10-13	9-26	11-2	11-14	9-16	10-20	10-5	11-9	11-17
F75-9187	9-4	10-9	9-24	11-2	11-16	9-14	10-17	10-4	11-7	11-16
Series 27										
F75-8756	8-30	10-3	9-19	10-31	11-16	9-12	10-11	9-30	11-6	11-21
F75-9415	9-3	10-10	9-25	11-3	11-17	9-14	10-19	10-5	11-9	11-20
F75-7089	8-29	9-30	9-14	10-24	11-8	9-9	10-7	9-23	10-30	11-11
F75-7093	8-30	10-1	9-14	10-26	11-10	9-11	10-8	9-25	10-31	11-13
F75-7220	8-27	9-30	9-15	10-26	11-10	9-6	10-8	9-22	10-31	11-13
F75-8768	9-1	10-4	9-19	10-30	11-16	9-12	10-11	9-26	11-4	11-19
F75-6920	8-30	10-1	9-16	10-26	11-13	9-9	10-9	9-26	11-1	11-20
F75-6863	8-29	10-1	9-15	10-27	11-17	9-10	10-6	9-25	11-1	11-18
F75-7041	8-30	10-1	9-16	10-25	11-10	9-10	10-8	9-23	10-30	11-12
F75-8742	8-29	10-3	9-18	10-28	11-14	9-12	10-12	9-29	11-7	11-20
F75-6923	8-29	9-29	9-14	10-26	11-10	9-5	10-7	9-22	10-30	11-12
F75-7102	8-30	10-2	9-15	10-25	11-10	9-11	10-8	9-24	10-26	11-12

Appendix Table 2 - Continued

	July 15 Planting					August 3 Planting				
Cultivar or line	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R7)	Ready for Harvest	Flowering Started	Flowering Ended	Beginning of Pod Filling (R5)	Physiological Maturity (R5)	Ready for Harvest
Series 28										
F73-9564	8-30	10-3	9-18	10-30	11-9	9-9	10-9	9-26	11-4	11-18
F71-1606	8-29	10-11	9-16	10-28	11-15	9-8	10-6	9-25	10-31	11-17
F74-9458	9-3	10-9	9-22	11-3	11-14	9-14	10-18	10-4	11-9	11-18
F73-9341	8-26	10-1	9-14	10-27	11-9	9-9	10-8	9-26	11-2	11-18
F73-9415	9-2	10-8	9-22	11-3	11-15	9-14	10-17	10-4	11-10	11-19
F73-9351	9-3	10-4	9-21	10-29	11-13	9-14	10-11	9-30	11-4	11-15
F73-9741	8-30	9-30	9-15	10-26	11-11	9-9	10-7	9-25	10-30	11-18
F67-5132	9-7	10-6	9-24	10-30	11-9	9-20	10-15	10-5	11-6	11-17
Control										
Jupiter Sel.	9-12	10-12	9-28	11-4	11-15	9-22	10-24	10-10	11-16	11-24
Vicoja	9-1	9-30	9-15	10-25	11-5	9-10	10-6	9-25	10-31	11-11
UFV-1	9-5	10-4	9-22	10-31	11-11	9-14	10-11	10-1	11-6	11-17
Cobb	8-29	10-3	9-16	10-28	11-10	9-9	10-10	9-24	11-1	11-16
Santa Rosa	9-2	10-8	9-20	10-28	11-8	9-14	10-12	10-1	11-3	11-15
Miniera	9-3	10-4	9-19	10-30	11-12	9-13	10-10	9-29	11-6	11-18

Appendix Table 3. The flowering pattern and life cycle of 129 soybean cultivars or lines planted on two planting dates at Gainesville, FL in 1976.

Cultivar or line	Days from planting to start of flowering		Length of flowering period (Days)		Length of pod filling period (Days)		Days from end of flowering to physiological maturity		Days from physiological maturity to harvest		Length of life cycle (days)	
	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6
Series 23												
F74-2064	39	31	22	26	50	44	41	33	11	9	102	90
F74-2080	39	32	21	25	52	42	44	32	9	9	104	89
F74-2023	40	35	24	26	48	43	38	32	11	10	102	93
F74-1993	40	36	21	28	46	39	39	26	8	7	100	90
F74-2774	41	31	20	22	47	44	40	36	11	9	101	89
F74-2678	41	35	27	27	47	41	34	28	11	7	102	90
F74-2001	41	35	23	28	42	41	33	28	11	7	97	91
F74-2203	41	37	20	25	42	39	35	28	15	8	96	90
F74-1970	41	35	23	26	44	40	35	29	8	7	99	90
F74-2432	41	37	25	29	46	46	38	30	9	10	104	96
F74-1979	41	35	20	25	43	39	36	29	9	7	97	89
F74-2684	41	36	27	30	46	43	34	27	11	10	102	93
F74-2215	41	37	20	27	41	36	34	23	13	10	95	87
F74-2150	41	36	26	31	47	43	36	28	9	9	103	95
F74-2130	41	36	24	28	48	44	38	30	10	11	103	94
F74-2685	42	35	23	28	48	43	40	30	8	6	105	93
F74-1976	42	37	28	30	49	43	35	29	9	10	105	96
F74-2716	43	35	22	27	52	46	43	33	6	11	108	95
F74-2068	44	37	23	30	45	39	35	24	8	7	102	91
F74-2128	44	39	26	29	48	42	36	29	8	10	106	97
F74-2122	44	39	24	28	47	42	36	29	9	10	104	96
F74-2640	45	38	21	26	46	43	39	31	7	7	105	95
Series 24												
F73-7405	38	32	20	25	45	39	38	31	16	10	96	88
F73-9769	38	30	26	28	41	44	30	29	17	10	94	87

Appendix Table 3 - Continued

Cultivar or line	Days from planting to start of flowering		Length of flowering period (Days)		Length of pod filling period (Days)		Days from end of flowering to physiological maturity		Days from physiological maturity to harvest		Length of life cycle (days)	
	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6
Series 24												
F73-9581	38	32	28	27	34	36	22	24	22	12	88	83
F73-9793	39	32	23	26	37	42	27	29	17	8	89	87
F73-9772	40	34	20	25	43	41	35	31	14	9	95	90
F70-3198	40	33	23	25	46	46	37	31	13	10	100	89
F73-8451	41	34	23	27	41	42	32	31	16	8	96	92
F73-9751	41	37	20	23	44	40	36	31	10	9	97	91
F73-9789	42	38	19	23	45	40	37	30	11	8	98	91
F74-3491	42	36	25	28	45	39	34	25	12	9	101	89
F74-3489	42	35	29	36	47	46	35	24	9	11	106	95
F74-3493	42	37	28	30	48	44	35	27	8	9	105	94
F73-8346	43	35	24	28	50	43	39	30	6	7	106	93
F74-3510	43	40	29	33	48	41	33	24	8	11	105	97
F73-4163	43	32	25	26	46	41	35	29	10	9	103	87
F73-9613	43	35	28	28	34	33	21	18	19	13	92	81
F72-3984	44	35	24	26	42	40	32	29	13	9	100	90
F72-4798	44	38	24	28	46	39	34	27	11	10	102	93
F73-8384	44	35	22	26	46	44	37	32	8	10	103	93
F73-9335	46	36	25	28	41	39	33	25	7	7	104	89
F72-5823	46	40	29	31	44	42	34	27	6	9	109	98
F72-4637	46	36	27	25	43	41	31	34	8	9	104	95
Series 25												
F73-9797	39	31	25	26	50	50	40	39	8	9	104	96
F72-4028	40	34	24	27	43	42	34	31	14	9	98	92
F73-9569	40	34	25	29	42	38	31	23	15	11	96	86
F73-9583	40	33	22	26	43	41	35	29	11	8	97	88
F73-9341	41	35	25	30	47	43	37	29	11	13	103	94

Appendix Table 3 - Continued

Cultivar or line	Days from planting to start of flowering		Length of flowering period (Days)		Length of pod filling period (Days)		Days from end of flowering to physiological maturity		Days from physiological maturity to harvest		Length of life cycle (days)	
	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6
Series 25												
F73-9758	41	36	23	25	39	40	30	29	12	14	94	90
F73-9787	42	37	22	25	44	40	35	29	9	9	99	91
F73-8414	42	36	23	27	46	43	36	30	13	9	101	93
F71-1606	42	35	26	29	44	41	32	27	13	9	100	91
F73-8338	42	37	23	29	43	40	33	24	11	8	98	90
F73-9733	42	36	28	29	49	45	36	30	7	9	106	95
D73-9358	43	37	26	27	49	44	37	31	9	9	106	95
F67-1634	43	36	23	27	46	41	37	28	9	8	103	91
F73-9780	43	37	21	23	37	38	29	28	13	9	93	88
F73-9564	43	37	25	28	45	43	35	29	9	8	103	94
D73-9360	44	38	28	29	49	40	35	27	8	11	107	94
F73-9728	44	37	26	26	47	42	36	32	8	8	106	95
F73-9723	45	37	27	29	45	42	32	28	9	10	104	94
F73-9576	45	39	28	28	41	37	28	24	12	9	101	91
F74-3514	46	40	28	29	47	39	33	27	8	12	107	96
F73-9391	48	42	26	27	42	38	34	28	7	10	108	97
F73-9437	48	41	27	29	41	39	33	26	7	10	108	96
Series 26												
F75-7876	37	31	24	26	50	46	42	34	9	8	103	91
F75-7131	38	32	19	24	51	46	44	35	12	8	101	91
F73-7418	39	33	20	28	38	41	30	28	24	10	89	89
F75-7180	40	35	26	27	49	39	37	28	10	11	103	90
F75-6809	40	34	31	31	47	42	32	26	11	9	103	91
F75-7201	40	35	27	29	49	41	36	28	9	10	103	92
F75-6834	40	35	27	28	47	42	34	28	12	9	101	91
F75-7198	41	34	25	29	47	43	36	29	11	9	102	92

Appendix Table 3 - Contined

Cultivar or line	Days from planting to start of flowering		Length of flowering period (Days)		Length of pod filling period (Days)		Days from end of flowering to physiological maturity		Days from physiological maturity to harvest		Length of life cycle (days)	
	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6
Series 26												
F75-7211	41	37	27	30	47	40	34	24	9	8	102	91
F75-7147	41	37	26	30	48	41	36	25	6	9	103	92
F75-7941	42	36	23	28	51	46	41	32	7	9	106	96
F72-4631	45	39	31	30	44	41	29	27	7	7	105	96
F74-2155	45	39	29	31	45	42	32	27	8	10	106	97
F75-9179	46	40	29	30	42	40	34	27	6	10	109	97
F75-9189	47	40	28	30	40	37	32	23	6	8	107	93
F75-9194	47	40	28	29	38	39	31	27	7	8	106	96
F75-9187	47	39	29	31	41	41	32	26	6	9	108	96
F73-9351	47	41	26	28	40	38	33	28	6	10	106	97
F75-9204	48	40	29	31	41	40	31	25	6	8	108	96
F75-9027	50	42	23	29	42	37	37	27	7	13	110	98
Series 27												
F75-7220	38	33	30	28	49	43	35	29	9	10	103	90
F75-6923	39	32	21	25	46	41	38	30	13	9	98	87
F75-6867	40	36	24	28	40	40	30	25	19	9	94	89
F75-6969	40	34	23	27	42	36	34	24	14	10	97	85
F75-6863	41	37	21	26	45	40	35	27	15	7	97	90
F75-6934	41	36	27	30	41	40	28	23	14	8	96	89
F75-6920	41	37	27	28	44	40	31	25	12	8	99	90
F75-6893	41	37	22	27	42	36	32	22	16	10	95	86
F75-7085	41	36	26	27	36	37	24	23	21	12	91	86
F75-8721	41	36	28	30	51	44	36	28	8	9	105	94
F75-7089	41	37	24	29	39	38	30	22	14	10	95	88
F75-6885	42	38	27	29	45	41	32	26	11	8	101	93
F75-7128	42	36	27	29	36	37	22	21	21	11	91	86

Appendix Table 3 - Continued

Cultivar or line	Days from planting to start of flowering		Length of flowering period (Days)		Length of pod filling period (Days)		Days from end of flowering to physiological maturity		Days from physiological maturity to harvest		Length of life cycle (days)	
	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6
Series 27												
F75-7093	42	37	23	29	40	39	30	23	16	9	95	89
F75-7041	42	36	24	30	38	36	27	20	19	11	93	86
F75-8742	42	37	26	29	49	41	36	27	8	9	104	93
F75-7102	42	37	23	30	37	37	27	20	18	10	92	87
F73-9741	42	37	20	25	41	39	34	29	13	8	96	91
F75-8756	44	37	22	28	48	40	39	27	10	11	105	92
F73-9415	47	40	28	28	40	39	32	28	7	11	107	96
Series 28												
F73-7418	40	34	17	25	39	41	34	29	23	8	91	88
F71-1606	41	34	19	26	47	36	40	25	13	10	100	85
F73-9341	41	34	22	27	49	43	41	31	9	6	104	92
F73-9741	42	34	20	26	42	39	35	27	14	9	97	87
F73-9564	42	35	21	25	49	38	42	28	7	10	105	88
F69-2185	44	36	24	24	52	44	40	33	7	10	108	93
F73-9351	45	41	25	28	46	38	35	27	7	8	105	96
F73-9415	47	40	27	29	43	39	35	27	5	8	109	96
F73-9458	48	40	27	29	41	39	34	27	5	8	109	96
OS 14	48	40	28	30	41	39	33	27	6	7	109	97
F67-5132	53	48	25	22	39	37	31	30	7	9	109	100
F72-5540	56	50	25	23	39	37	33	31	8	8	114	104
F72-5545	56	50	25	23	41	37	33	32	8	7	114	105
F69-2143	57	50	24	23	41	38	34	32	8	7	115	105
F72-5532	57	50	24	23	42	36	35	32	7	8	116	105
G72-279	57	50	24	23	42	38	34	32	7	8	115	105
G72-312	57	50	25	23	41	38	33	32	8	8	115	105

Appendix Table 3 - Continued

Cultivar or line	Days from planting to start of flowering		Length of flowering period (Days)		Length of pod filling period (Days)		Days from end to flowering to physiological maturity		Days from physiological maturity to harvest		Length of life cycle (days)	
	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6	Jul 20	Aug 6
Control												
Cobb	41	34	20	29	50	46	44	32	9	8	105	95
Vicoja	44	38	25	28	41	39	30	26	9	7	99	92
Santa Rosa	46	40	27	30	42	40	31	26	7	8	104	96
Miniera	46	40	24	28	44	41	33	28	8	9	103	96
UFV-1	50	44	24	27	42	34	35	27	7	10	109	98
Jupiter Sel.	56	49	25	24	43	40	34	33	7	6	115	106

Appendix Table 4. The flowering pattern, periods of various productive phases and life cycle of 84 soybean cultivars or lines planted on two dates at Gainesville, FL in 1977.

Cultivar or line	Days from planting to start of flowering		Length of flowering period (Days)		Length of pod filling period (Days)		Days from end of flowering to physiological maturity		Days from physiological maturity to harvest		Length of life cycle (days)	
	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3
Series 23												
F74-2080	42	34	33	32	42	39	29	24	14	13	104	90
F74-2128	48	41	32	27	40	36	26	26	17	14	106	94
F74-2068	46	39	33	28	39	35	24	22	12	12	103	89
F74-2684	45	37	33	31	43	37	27	23	16	14	105	91
F74-2150	46	36	33	32	42	37	26	23	13	16	105	91
F74-2122	48	40	33	28	40	37	24	26	18	14	105	94
F74-2023	42	38	34	29	41	39	27	26	19	17	103	93
F74-1993	45	37	31	29	40	36	24	23	15	15	100	89
F74-1979	45	37	31	28	39	33	25	22	14	14	101	87
F74-2685	46	38	34	29	44	39	28	25	14	16	108	92
F74-2001	45	38	33	27	38	35	23	25	11	12	101	90
F74-2215	46	39	31	26	36	33	22	21	14	12	99	86
F74-1976	46	40	34	30	42	38	26	24	17	16	106	94
F74-2203	46	39	30	27	40	34	25	22	16	16	101	88
F74-2640	48	40	32	27	44	38	30	27	13	13	110	94
F74-2774	45	33	32	28	40	38	27	26	12	13	104	87
Series 24												
F74-3489	45	37	36	33	44	40	27	24	15	14	108	94
F72-4637	48	43	34	29	38	33	29	21	11	13	111	93
F74-3493	46	34	35	31	44	41	27	26	15	13	108	96
F72-5823	49	42	37	30	42	39	25	26	11	9	111	98
F74-3491	46	39	33	29	40	36	26	22	17	17	105	90
F73-8384	46	40	34	29	45	41	29	27	13	11	109	96
F73-8346	46	37	33	30	43	39	27	26	12	13	106	93

Appendix Table 4 - Continued

Cultivar or line	Days from planting to start of flowering		Length of flowering period (Days)		Length of pod filling period (Days)		Days from end of flowering to physiological maturity		Days from physiological maturity to harvest		Length of life cycle (days)	
	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3
Series 24												
F72-4163	45	30	34	29	40	35	24	23	14	14	103	90
F72-4798	46	40	33	29	42	35	25	22	14	16	104	91
F72-3984	46	40	30	28	43	35	27	22	15	16	103	90
F74-3510	44	38	38	32	41	36	23	22	14	13	105	92
F73-9335	46	40	35	30	40	38	25	24	12	12	106	94
F73-9613	45	40	33	26	38	33	23	22	14	12	101	88
F73-9789	47	39	30	26	39	36	26	25	14	13	103	90
Series 25												
F73-9341	44	36	34	30	44	38	27	25	14	15	105	91
F73-9583	43	33	34	31	45	38	28	25	13	11	105	89
F73-9564	46	37	36	31	44	38	27	25	9	12	109	93
F74-3514	49	41	37	31	42	37	22	23	15	14	108	95
F73-9733	46	38	35	31	44	40	28	26	14	13	109	95
F73-9723	48	40	37	30	45	37	25	23	13	16	110	93
F73-9728	46	39	36	32	45	38	28	22	14	14	110	93
F73-9797	43	33	32	28	47	40	32	29	10	13	107	90
F73-9391	52	44	33	27	40	36	26	26	12	11	111	97
D73-9358	45	38	35	30	45	41	29	28	13	12	109	96
F71-1606	45	37	33	28	44	39	27	26	19	16	105	91
D73-9360	45	39	36	30	45	40	29	27	13	12	110	96
F73-9758	43	37	32	27	41	35	25	22	16	14	100	86
F73-9569	44	35	33	29	42	37	27	24	14	14	104	88
Series 26												
F75-9207	54	44	35	34	38	36	24	22	10	7	113	100
F75-7941	43	37	36	32	44	39	26	25	14	14	105	94

Appendix Table 4 - Continued

Cultivar or line	Days from planting to start of flowering		Length of flowering period (Days)		Length of pod filling period (Days)		Days from end of flowering to physiological maturity		Days from physiological maturity to harvest		Length of life cycle (days)	
	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3
Series 26												
F74-2155	47	41	34	28	42	35	27	24	13	14	108	93
F75-7147	45	38	35	30	41	37	23	22	11	16	103	90
F75-7180	44	37	31	30	42	38	27	22	17	17	102	89
F75-9194	51	42	36	33	38	35	23	21	13	10	110	96
F75-9204	52	43	37	35	37	35	21	20	13	8	110	98
F75-7211	45	38	36	30	40	36	21	21	13	15	102	89
F73-7418	44	35	32	30	40	36	24	24	20	15	100	89
F75-9179	46	42	40	34	41	37	25	22	15	10	111	98
F75-7201	45	38	34	30	42	38	24	22	15	14	103	90
F75-6834	45	38	33	31	42	40	24	24	17	14	102	93
F75-9205	53	44	37	34	37	35	20	20	12	8	110	98
F75-9187	51	42	36	33	38	35	33	21	13	9	110	96
Series 27												
F75-8756	46	40	34	29	42	37	28	26	16	15	108	95
F75-9415	50	42	37	35	39	35	24	21	14	11	111	98
F75-7089	45	37	32	28	40	37	24	23	15	12	101	88
F75-7093	46	39	32	27	42	36	25	23	15	13	103	89
F75-7220	43	34	34	32	41	39	26	23	15	13	103	89
F75-8768	48	40	33	29	41	39	26	24	17	15	107	93
F75-6920	46	37	32	30	40	36	25	23	18	19	103	90
F75-6863	45	38	33	26	42	37	26	26	21	17	104	90
F75-7041	46	38	32	28	39	37	24	22	16	13	102	88
F75-8742	45	40	35	30	40	39	25	26	17	13	105	96
F75-6923	45	33	31	32	42	38	27	23	15	13	103	88
F75-7102	46	39	33	27	40	32	23	18	16	17	102	84

Appendix Table 4 - Continued

Cultivar or line	Days from planting to start of flowering		Length of flowering period (Days)		Length of pod filling period (Days)		Days from end of flowering to physiological maturity		Days from physiological maturity to harvest		Length of life cycle (days)	
	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3	Jul 15	Aug 3
Series 28												
F73-9564	46	37	34	30	42	39	27	26	10	14	107	93
F71-1606	45	36	33	28	42	36	27	25	18	17	105	89
F74-9458	50	42	36	34	42	36	25	22	11	9	111	98
F73-9341	42	37	36	29	43	37	26	25	13	16	104	91
F73-9415	49	42	36	33	42	37	26	24	12	9	111	99
F73-9351	50	42	31	27	38	35	25	24	15	11	106	93
F73-9741	46	37	31	28	41	35	26	23	15	19	103	88
F67-5132	54	48	29	25	36	32	24	22	10	11	107	95
Control												
Jupiter Sel.	59	50	30	32	37	37	23	23	11	8	112	105
Vicoja	48	38	29	26	40	36	25	25	11	11	102	89
UFV-1	52	42	29	27	39	36	27	26	11	13	108	95
Cobb	45	37	35	31	42	38	25	22	13	15	105	90
Santa Rosa	49	42	36	28	38	33	20	22	11	12	105	92
Miniera	50	41	31	27	41	38	26	27	13	12	107	95

Appendix Table 5. Plant height at flowering and maturity, height to lowest seed pod above soil and seed yield of 129 soybean cultivars or lines at two planting dates at Gainesville, FL in 1976.

Cultivars or lines	July 20 Planting				August 6 Planting			
	Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)	Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed Yield (kg/ha)
Series 23								
F74-2064	37	57	9	2990	30	51	8	1530
F74-2080	34	58	11	3570	21	37	4	-
F74-2023	44	65	14	3290	39	54	12	2500
F74-1993	43	69	18	3210	38	54	12	1870
F74-2774	38	41	2	4000	19	24	1	1430
F74-2678	40	50	3	-	28	31	4	-
F74-2001	36	51	11	3400	31	42	7	-
F74-2203	49	71	19	2920	38	56	11	2420
F74-1970	36	59	15	3030	32	43	8	1720
F74-2432	37	59	9	3140	36	51	9	2180
F74-1979	34	53	13	2920	33	40	8	1880
F74-2684	40	63	10	3810	34	51	7	1980
F74-2215	50	59	19	3540	39	54	14	2140
F74-2150	44	66	10	2860	36	56	7	2230
F74-2130	39	59	11	3040	35	43	6	2040
F74-2685	39	55	10	3280	31	40	5	2180
F74-1976	39	48	9	2790	31	52	4	2200
F74-2716	38	57	9	-	27	38	4	1410
F74-2068	53	71	20	2860	37	52	12	3070
F74-2128	51	77	15	3850	42	62	14	3010
F74-2122	54	70	17	2710	41	59	12	2750
F74-2640	41	63	15	2980	28	41	5	2540
Series 24								
F73-7405	36	54	7	2810	27	40	5	-
F73-9769	25	38	2	-	20	33	3	1170

Appendix Table 5 - Continued

Cultivars or lines	July 20 Planting: Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)	August 6 Planting: Plant height at flowering (cm	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)
Series 24								
F73-9581	30	52	1	-	22	29	2	-
F73-9793	26	38	2	-	20	33	2	-
F73-9772	27	43	6	2920	22	43	4	2520
F70-3198	22	27	0	-	23	30	0	-
F73-8451	28	36	0	-	23	30	0	-
F73-9751	35	53	12	3080	30	39	5	-
F73-9789	36	49	9	2990	28	36	6	2280
F74-3491	38	56	9	3490	31	41	7	1740
F74-3489	38	50	6	3620	32	43	4	2740
F74-3493	39	58	11	3100	39	47	10	2070
F73-8346	35	49	5	3350	30	43	4	2320
F74-3510	42	59	9	3540	36	55	7	2550
F72-4163	35	48	9	-	31	43	9	-
F73-9613	34	55	7	-	33	40	4	-
F72-3984	44	55	7	2440	29	46	5	-
F72-4798	34	49	6	3650	33	45	6	-
F73-8384	38	50	12	2260	32	36	6	2870
F73-9335	47	61	15	3020	35	42	7	2530
F72-5823	52	79	18	3870	38	58	10	2100
F72-4637	38	50	12	-	32	36	6	-
Series 25								
F73-9797	27	37	6	3330	23	43	5	1800
F72-4028	31	41	5	-	22	38	4	1720
F73-9569	31	44	5	3250	25	35	4	-
F73-9583	26	50	8	3230	26	36	4	-

Appendix Table 5 - Continued

Cultivars or lines	July 20 Planting: Plant height at flowering (cm)	July 20 Planting: Plant height at maturity (cm)	July 20 Planting: Lowest pod height (cm)	July 20 Planting: Seed yield (kg/ha)	August 6 Planting: Plant height at flowering (cm)	August 6 Planting: Plant height at maturity (cm)	August 6 Planting: Lowest pod height (cm)	August 6 Planting: Seed yield (kg/ha)
Series 25								
F73-9341	31	43	5	3670	28	45	5	-
F73-9758	29	41	8	3070	32	41	5	2280
F73-9787	34	49	10	2910	29	37	8	930
F73-8414	36	41	2	-	28	39	2	-
F71-1606	39	48	6	3650	30	43	6	-
F73-8338	33	50	9	2620	29	37	6	-
F73-9733	46	68	10	3560	32	57	6	2400
D73-9358	32	39	6	2620	30	34	3	-
F67-1634	40	56	10	2810	28	40	6	-
F73-9780	29	35	5	-	26	30	5	-
F73-9564	36	59	9	3600	33	40	3	1800
D73-9360	37	47	6	3230	26	37	3	1310
F73-9728	44	67	10	3430	35	57	8	1940
F73-9723	43	60	9	3450	38	52	9	2020
F73-9576	45	55	12	2950	38	47	7	2100
F74-3514	55	67	9	3530	42	63	9	1570
F73-9391	51	71	15	3180	43	61	14	2300
F73-9437	46	67	13	3040	34	51	7	2240
Series 26								
F75-7876	33	52	9	3370	22	34	2	1760
F75-7131	38	49	7	3430	27	39	7	2240
F73-7418	29	46	6	-	30	47	4	-
F75-7180	39	55	7	3770	31	42	7	2770
F75-6809	43	58	7	-	38	49	6	-
F75-7201	36	52	7	3370	34	48	6	2730
F75-6834	42	56	7	2480	38	52	5	2390

Appendix Table 5 - Continued

Cultivars or lines	July 20 Planting				August 6 Planting			
	Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)	Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)
Series 26								
F75-7198	38	61	13	3390	35	48	5	-
F75-7211	41	63	12	3900	38	50	9	1630
F75-7147	47	56	14	3970	39	50	11	1650
F75-7941	40	61	11	3140	34	54	8	2600
F72-4631	36	57	9	3530	19	38	4	-
F74-2155	62	81	19	3140	52	79	17	2760
F75-9179	48	78	21	2870	40	58	11	2100
F75-9189	46	73	17	2710	29	49	7	1650
F75-9194	45	74	20	2700	33	54	9	2790
F75-9187	47	79	19	3550	35	58	7	1760
F73-9351	43	59	16	2680	37	49	9	2120
F75-9204	57	89	27	3540	43	68	22	2410
F75-9207	57	101	27	3150	38	62	11	2110
Series 27								
F75-7220	34	63	11	4010	30	51	7	1470
F75-6923	36	59	13	2810	29	42	5	-
F75-6867	42	55	9	-	36	44	6	-
F75-6969	36	47	7	2890	30	37	5	-
F75-6863	40	64	15	3030	39	59	10	2170
F75-6934	25	59	13	3010	35	47	8	1780
F75-6920	43	61	14	3200	40	54	10	2220
F75-6893	37	52	7	2790	34	41	6	-
F75-7085	43	60	12	2810	28	44	6	1610
F75-8721	46	71	14	-	40	60	12	1290
F75-7089	46	59	16	3360	36	43	7	1750

Appendix Table 5 - Continued

Cultivars or lines	July 20 Planting				August 6 Planting			
	Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)	Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)
Series 27								
F75-6885	44	57	10	2870	38	55	9	-
F75-7128	47	58	9	-	38	46	7	-
F75-7093	40	58	12	-	34	47	8	1860
F75-7041	44	58	13	-	32	46	7	1900
F75-8742	46	66	17	3330	39	53	14	2390
F75-7102	49	66	18	3100	38	54	12	1900
F73-9741	36	55	16	3280	28	49	8	2150
F75-8756	48	71	16	3100	36	50	9	-
F73-9415	52	74	19	3150	33	45	7	2740
Series 28								
F73-7418	43	60	10	-	32	48	9	2200
F71-1606	47	68	18	4040	33	42	8	-
F73-9341	38	60	7	3070	26	45	7	2490
F73-9741	48	60	17	3090	30	53	11	2470
F73-9564	41	65	13	4550	25	43	5	1770
F69-2185	46	63	15	3260	39	45	5	2440
F73-9351	50	68	22	3330	37	53	16	2140
F73-9415	52	73	20	3400	36	47	12	1900
F73-9458	54	65	10	3610	38	52	8	2370
OS 14	60	80	23	2740	41	63	13	2040
F67-5132	55	73	21	2810	48	64	17	1690
F72-5540	73	97	22	3650	60	90	22	1290
F72-5545	73	96	21	-	60	90	20	1530
F69-2143	77	91	27	-	63	87	24	1330
F72-5532	82	112	35	2870	61	96	30	820

Appendix Table 5 - Continued

Cultivars or lines	July 20 Planting				August 6 Planting			
	Plant height at flowering	Plant height at maturity	Lowest pod height	Seed yield	Plant height at flowering	Plant height at maturity	Lowest pod height	Seed yield
	(cm	(cm)	(cm)	(kg/ha)	(cm)	(cm)	(cm)	(kg/ha)
Series 28								
G72-279	82	106	28	-	59	97	24	1010
G72-312	78	101	27	3030	58	96	24	1110
Control								
Cobb	31	52	7	3310	30	50	7	2320
Vicoja	42	59	14	2910	34	45	8	2030
Santa Rosa	50	69	18	3110	34	56	8	3130
Miniera	41	57	13	3360	32	46	7	2030
UFV-1	54	70	22	3010	43	56	15	1750
Jupiter Sel.	78	100	24	3170	58	84	20	960

Appendix Table 6. Plant height at flowering and maturity, height to lowest seed pod above soil and seed yield of 84 soybean cultivars or lines at two planting dates at Gainesville, FL in 1977.

Cultivars or lines	July 15 Planting: Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)	August 3 Planting: Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)
Series 23								
F74-2080	63	66	15	3550 a-d	20	37	4	1770 a-k
F74-2128	68	81	20	3540 a-d	32	46	11	1750 a-k
F74-2068	72	85	24	3310 a-h	33	48	13	1770 a-k
F74-2684	73	75	18	3130 a-j	31	46	6	1990 a-h
F74-2150	68	75	18	3080 a-f	30	43	8	1770 a-k
F74-2122	72	85	24	2950 a-l	32	48	9	1900 a-i
F74-2023	70	80	20	2940 a-l	35	52	10	1800 a-k
F74-1993	67	76	16	2880 a-l	30	43	9	1910 a-i
F74-1979	66	66	15	2880 a-l	25	34	7	1300 h-k
F74-2685	55	56	10	2710 a-l	21	31	6	2040 a-g
F74-2001	61	65	14	2690 a-l	27	31	7	1480 d-k
F74-2215	62	67	16	2690 a-l	30	37	8	1230 ijk
F74-1976	54	63	11	2630 c-l	31	44	6	2180 a-e
F74-2203	61	70	19	2370 h-l	33	45	10	1490 d-k
F74-2640	63	68	10	2280 i-l	29	36	5	2110 a-g
F74-2774	55	56	9	2210 jkl	21	24	0	1110 j-k
Series 24								
F74-3489	63	65	11	3610 ab	28	35	5	1830 a-j
F72-4637	55	68	14	3610 ab	25	40	8	1690 a-k
F74-3493	67	70	12	3600 abc	27	35	5	2000 a-h
F72-5823	64	86	22	2530 a-e	32	49	11	2140 a-f
F74-3491	62	66	12	3140 a-j	27	33	6	1920 a-i
F73-8384	56	58	13	3000 a-l	27	35	7	1940 a-i

Appendix Table 6 - Continued

Cultivars or lines	July 15 Planting: Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)	August 3 Planting: Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)
Series 24								
F73-8346	67	62	14	2950 a-l	27	38	6	1750 a-k
F72-4163	66	80	20	2910 a-l	30	40	10	1460 e-k
F72-4798	56	66	15	2900 a-l	26	38	9	1540 c-k
F72-3984	57	63	13	2830 a-l	28	40	6	1630 b-k
F74-3510	71	80	12	2820 a-l	31	42	9	2200 a-d
F73-9335	66	79	14	2620 d-l	32	37	6	2000 a-h
F73-9613	62	69	17	2560 e-l	28	35	8	1080 k
F73-9789	59	57	13	2480 f-l	27	34	5	1440 f-k
Series 25								
F73-9341	64	67	12	3570 a-d	23	35	4	1690 a-k
F73-9583	67	75	16	3510 a-e	24	35	3	1990 a-h
F73-9564	56	63	12	3390 a-f	29	36	3	1890 a-i
F74-3514	77	79	13	3300 a-h	38	53	8	2410 a
F73-9733	65	81	12	3270 a-h	29	43	7	1940 a-i
F73-9723	63	69	13	3210 a-i	29	41	6	1800 a-k
F73-9728	67	73	16	3160 a-j	33	48	8	2210 a-d
F73-9797	67	69	14	3120 a-j	26	41	8	2190 a-e
F73-9391	61	73	21	3070 a-j	32	49	10	1800 a-k
F73-9358	63	67	12	3060 a-j	25	33	5	2080 a-g
F71-1606	65	77	19	3050 a-k	31	40	6	2100 a-g
D73-9360	65	67	13	2970 a-l	27	35	4	1960 a-i
F73-9758	63	68	13	2900 a-l	29	37	6	1620 b-k
F73-9569	62	66	12	2350 h-l	28	36	6	1680 a-k

Appendix Table 6 - Continued

Cultivars or lines	Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)	Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)
Series 26								
F75-9207	67	94	25	3540 a-d	29	45	10	1790 a-k
F75-7941	63	66	16	3380 a-g	30	39	5	1880 a-i
F74-2155	75	95	26	3250 a-i	38	55	13	1860 a-i
F75-7147	64	72	16	3100 a-j	30	40	7	1660 b-k
F75-7180	70	81	18	3040 a-k	33	47	7	1970 a-h
F75-9194	60	81	18	3020 a-1	28	49	11	1990 a-h
F75-9204	70	93	26	2980 a-1	29	54	13	2090 a-g
F75-7211	71	75	18	2900 a-1	31	47	8	2130 a-f
F73-7418	72	80	14	2880 a-1	29	42	7	1530 c-k
F75-9179	67	88	21	2870 a-1	30	44	7	1880 a-i
F75-7201	69	73	18	2850 a-1	32	41	7	1630 b-k
F75-6834	68	71	14	2780 a-1	31	43	6	1890 a-i
F75-9205	60	65	12	2690 a-1	24	40	5	1750 a-k
F75-9187	63	87	20	2650 b-1	32	50	12	2050 a-g
Series 27								
F75-8756	67	78	19	3140 a-j	33	46	7	1960 a-i
F75-9415	67	80	20	2910 a-1	31	41	10	1650 b-k
F75-7089	70	77	22	2860 a-1	34	42	9	1650 b-k
F75-7093	62	71	16	2840 a-1	28	40	9	1710 a-k
F75-7220	64	78	13	2730 a-1	22	40	5	1380 g-k
F75-8768	60	68	17	2650 b-1	31	42	8	1910 a-i
F75-6920	72	80	19	2550 e-1	31	51	11	1620 b-k
F75-6863	68	81	17	2460 f-1	37	55	12	1850 a-i
F75-7041	61	67	15	2420 f-1	31	39	8	1790 a-k
F75-8742	63	74	19	2410 g-1	30	43	8	1710 a-k
F75-6923	53	63	15	2380 h-1	22	36	5	1530 c-k
F75-7102	62	69	14	2080 kl	37	14	10	1740 a-k

Appendix Table 6 - Continued

Cultivars or lines	July 15 Planting				August 3 Planting			
	Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)	Plant height at flowering (cm)	Plant height at maturity (cm)	Lowest pod height (cm)	Seed yield (kg/ha)
Series 28								
F73-9564	58	67	11	3660 a	25	37	4	2080 a-g
F71-1606	69	79	23	3390 a-f	31	49	9	2040 a-g
F74-9458	66	87	21	3320 a-h	33	50	12	2310 ab
F73-9341	59	63	12	3290 a-h	25	36	3	1570 c-k
F73-9415	74	83	20	2970 a-l	33	40	11	2260 abc
F73-9351	62	69	17	2770 a-l	30	46	11	1870 a-i
F73-9741	76	84	22	2390 h-l	29	37	4	1620 b-k
F67-5132	55	65	18	2060 l	30	45	12	1080 k
Control								
Jupiter Sel.	83	105	24	3110 a-j	45	64	13	1490 d-k
Vicoja	67	71	17	3100 a-j	30	41	7	1410 f-k
UFV-1	67	81	20	2600 d-l	32	40	9	1620 b-k
Cobb	43	53	7	2440 f-l	31	40	6	2200 a-d
Santa Rosa	58	68	17	2400 h-l	32	41	9	1520 c-k
Miniera	58	66	14	2380 h-l	31	34	5	1660 b-k

*Seed yield not followed by the same letter(s) are significantly different at 5% level.

Appendix Table 7. Climatological data for Gainesville, FL (monthly average for 1976 and 1977).

	1976				1977				
	Temperature F				Temperature F				Day
Month	Max.	Min.	Rainfall (inches)	Pan Evap. (inches)	Max.	Min.	Rainfall (inches)	Pan Evap. (inches)	Length (hours)
Jan.	67.9	39.3	1.20	2.66	60.4	36.2	3.35	2.74	10.45
Feb.	75.4	46.8	1.49	4.18	68.4	40.5	4.16	4.23	11.13
Mar.	81.2	54.9	1.46	5.48	80.8	56.7	1.22	5.92	11.93
Apr.	82.2	55.4	3.19	6.47	83.2	55.4	0.83	7.41	12.90
May	84.9	63.2	6.38	6.05	89.5	62.6	0.46	8.30	13.66
Jun.	88.1	67.9	11.37	5.81	95.7	70.5	2.26	9.35	14.05
Jul.	92.5	71.1	4.59	7.02	95.1	71.9	1.44	8.13	13.84
Aug.	91.1	71.0	2.84	6.04	92.1	73.0	7.10	6.05	13.27
Sep.	88.8	68.2	5.36	5.00	91.1	71.9	5.72	5.51	12.34
Oct.	80.4	55.5	2.21	4.94	81.6	56.5	0.13	4.77	11.46
Nov.	70.9	45.4	2.78	2.81	77.5	55.1	1.95	3.31	10.69
Dec.	67.6	44.9	4.97	2.05	68.6	45.4	4.94	2.24	10.43

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BIOGRAPHICAL SKETCH

The author, Md. Abdul Muttalib Akhanda, was born on June 15, 1937, in Betbari village of Mymensingh district in Bangladesh. He received primary education from Katagila Primary School and graduated from Assim High School in 1952 with distinction in mathematics. He studied two years at Sa-adat College, Korotia, Tangail district and obtained a diploma in Intermediate Science (I. Sc.) in 1955.

In 1959, he received Bachelor of Agriculture in Agronomy (B. Ag.) degree from Dacca Agricultural College and Master of Agriculture (M. Ag.) degree from Dacca University in 1960. From 1961 to 1964, he served as a Lecturer in Agronomy at the Agricultural College, Dacca. From July 1964 to December 1966 he took training in Rice Agronomy at the International Rice Research Institute (IRRI) in the Philippines with a Ford Foundation Scholarship. During his tenure at IRRI he received the M. S. in Agronomy degree from the College of Agriculture, University of the Philippines in 1966.

On return from the IRRI, he joined the Bangladesh Academy for Rural Development, Kotbari, Comilla, as the Agronomist and worked until August 1974. During this period of service, he made a number of publications on agricultural practices and problems on various crops, visited Japan to study agricultural cooperatives in 1969, presented a paper and participated in a month and a half long study

seminar organized by the Institute of Development Studies of the University of Sussex, London at Kandy, Sri-Lanka in 1973. He is a co-author of two books: 'Krishi-O-Mrittika Bignan," an agricultural textbook for high schools and "Krishiprodorshika," a guidebook on agriculture for primary school teachers, published by the Ministry of Education of Bangladesh.

In September 1974, he entered the Graduate School of the University of Florida with a Ford Foundation Graduate fellowship for the degree of Doctor of Philosophy in Agronomy with major interest in tropical multiple cropping.

Mr. Akhanda is a member of the Honor Society of Agriculture, Gamma Sigma Delta. He is happily married to Jahanara Begum (Minu), and they have a daughter, Flora, and two sons, Philip and Tushar.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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